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Rio Blanco Oil Shale Company

MODULAR DEVELOPMENT PHASE MONITORING REPORT ONE

VOLUME 1 OF 2

SEPTEMBER 1977 THRU NOVEMBER 1977
YEAR END REPORT

Gulf Oil Corporation
and
Standard Oil Company (Indiana)
A General Partnership
9725 East Hampden Avenue, Denver, Colorado 80231

U.S. DEPARTMENT OF INTERIOR
OIL SHALE
ENVIRONMENTAL ADVISORY PANEL
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RIO BLANCO OIL SHALE COMPANY
MODULAR DEVELOPMENT PHASE
MONITORING REPORT 1

September - November 1977
YEAR-END REPORT

SUBMITTED TO
RIO BLANCO OIL SHALE COMPANY
DENVER, COLORADO

PREPARED BY
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DENVER, COLORADO

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February 15, 1978

U. S. DEPARTMENT OF INTERIOR
OIL SHALE
ENVIRONMENTAL ADVISORY PANEL
Denver Federal Center

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SECTION 1

INTRODUCTION

In 1969, the U. S. Department of the Interior initiated planning for a prototype oil shale leasing program that eventually resulted in Gulf Oil Corporation and Standard Oil Company (Indiana) acquiring an oil shale lease for Tract C-a in the Piceance Creek basin of northwest Colorado. Gulf and Standard submitted the high bonus bid for Tract C-a ($210,305,600) at a lease sale in Denver on January 8, 1974. Rio Blanco Oil Shale Project (RBOSP), an organization directed and staffed by representatives of Gulf and Standard, was formed later that year for the purpose of developing the tract. Recently, the RBOSP has been formed into a general partnership called the Rio Blanco Oil Shale Company (RBOSC).

After its inception in 1974, the RBOSC conducted extensive geotechnical and environmental data collection programs to define baseline conditions on and around Tract C-a. Results of these studies were subsequently used to prepare the Detailed Development Plan (DDP) describing Gulf-Standard's plans for developing the tract. The first DDP concept, issued in March 1976, presented the companies' concepts for open pit mining to develop the tract. Legal and environmental restraints prevented the implementation of this plan. A subsequent revised plan was developed and released in May 1977. This revised DDP presented a plan for developing the oil shale tract by modified in situ (MIS) mining methods. The revised plan was approved by the Area Oil Shale Supervisor (AOSS) on September 22, 1977.

Following approval of the revised DDP the RBOSC began Modular Development Phase (MDP) activities as described in the approved DDP, including the MDP Environmental Monitoring Program. The environmental monitoring program was initiated in September 1977. It complements the baseline and interim studies data (taken from October 1974 - October 1976 and November 1976 - August 1977, respectively) and launches the impact assessment phase for environmental studies.

The MDP Environmental Monitoring Program is designed to collect air quality, meteorology, terrestrial ecology, aquatic ecology, and hydrology data. Monitoring program designs are based on analysis of baseline and interim studies data, an assessment of probable developmental impacts, and recommendations from the Area Oil Shale Office (AOSO). Although it is expected to go through revision, the current monitoring program is described in the RBOSP Modular

Development Phase Environmental Monitoring Program Scope of Work dated December 7, 1977. This scope of work reflects the environmental monitoring philosophy set forth in the revised DDP. However, the AOSS has indicated that his office plans to prepare a list of "minimal monitoring requirements" which will outline a basic program for all tracts. Once the AOSO program is released, RBOSC expects to revise their program to conform with the AOSO list.

NUS Corporation is the lead environmental contractor, responsible for air quality, meteorology, terrestrial ecology and aquatic ecology studies. Hydrology studies are being conducted by Wright Water Engineers and the United States Geological Survey (USGS). Dames and Moore will be collecting basin-wide visibility data and Morrison-Knudsen will be collecting noise data.

Data collected during monitoring studies will be reported semi-annually, in a mid-year and a year-end report. This report, Monitoring Report 1, is the first year-end report. It covers the period September-November 1977. This report presents a brief review of previously conducted studies, a summary of the Fall season's data, interpretative discussions of the Fall data, comparisons of the Fall 1977 data with previous Fall data where applicable, and notations on impacts caused by initial development activities, if noted.

Objectives of the monitoring program and methods to be implemented to accomplish these objectives are described in this report. This information will not be presented in subsequent reports except where program revisions have been made. When data are available for the program they are presented and the results are discussed. This report contains six sections as follows;

Section 1 - Introduction
Section 2 - Atmospheric Studies
Section 3 - Terrestrial Studies
Section 4 - Aquatic Studies
Section 5 - Hydrology Studies
Section 6 - Summary

SECTION 2

ATMOSPHERIC STUDIES

The Tract C-a atmospheric studies program consists of two discrete parts--(1) measurements of total suspended particulate matter and certain chemical compounds in the ambient air, and (2) measurements of meteorology parameters to characterize the climatology of the Tract area. During this reporting period the level of activity in tract development was very low. One air quality and meteorology monitoring station was operated continuously throughout the reporting period, and two additional stations were re-established late in the period in anticipation of the start of the Modular Development Phase of tract development. A medium sized gas-well drilling rig was installed and operated for a period of several months at a location west of the tract boundary about two miles from the continuous monitoring station. A review of the air quality data did not show any measurable impact as a result of this operation.

Air quality and meteorology data have been obtained from monitoring instruments located on or near Tract C-a since February 1975. The first two years of data collection make up the baseline data set. Baseline data were obtained at four geographic locations surrounding the tract. The monitoring locations were established originally to provide a measure of the air quality of the atmosphere transported into the area by normal weather events and at points where future tract development might be expected to result in changes in ambient air quality. Meteorology measurements were made simultaneously with the air quality observations in order to provide a rationale for predicting the dispersion of emissions likely to occur with tract development.

During the baseline data period most of the general climate features of the tract area were established. These include: wind speed and direction frequencies, ambient temperatures, atmospheric stability characteristics, insolation, upper air behavior and precipitation. The baseline year's precipitation data are considered anomalous in that the entire western United States suffered a prolonged drought condition which undoubtedly affected the tract area.

The air quality measurements during the baseline period have established that the average concentration of total suspended particulate matter in the atmosphere is relatively low except where measured adjacent to unpaved public

access roads and then there is a pronounced seasonal variation. The concentrations of sulfur dioxide, hydrogen sulfide, nitric oxide and nitrogen oxides, and carbon monoxide are generally too low to register reliably on the equipment installed to detect them. Methane concentration in the ambient air fluctuated around the accepted global average background value. The measurements of total hydrocarbon concentration occasionally exceeded the level set by the National Air Quality Standards. The photochemical oxidant (as ozone) concentration exceeded the National Air Quality Standard only once during the period. Both of these pollutants are normally encountered in urban areas and are thought to be directly related to the operation of automobiles. The amount of automobile traffic on or around the tract is insignificant so some other natural source must be responsible unless very long range transport of urban pollutants into the tract areas is proven to be the source. It is unclear from the existing data whether the hydrocarbon and oxidant concentrations (ozone) are due to local sources or to long range transport.

Following the baseline data acquisition period an interim environmental data acquisition program was established to cover an interval during which the tract development lease conditions were modified and partially suspended. During this period (February to September 1977) a single air quality and meteorology monitoring station was operated to maintain data continuity. In most respects the interim data does not differ from the baseline data. The only significant variation occurs in the measurement of total suspended particulate. The difference is a result of a change in the methods of sample handling and analysis to conform to the most recent recommended procedures. During the interim period several air quality measurement methods were duplicated with alternative measurement methodologies to establish low level background concentrations of a pollutant where the average concentration is generally below the nominal threshold of detection of the automated instrumentation utilized in the continuous monitoring program.

2.1 AIR QUALITY

National Ambient Air Quality Standards have been adopted to establish the safe concentrations of certain pollutants in the ambient air. Air quality monitoring has been conducted on and near Tract C-a to establish the existing level of

these pollutants before tract development is initiated. It is expected that tract development activities will result in the emission of certain gases into the ambient air that have the potential for adversely affecting air quality.

Monitoring for gaseous pollutants in the ambient air was conducted at a location established at the outset of the baseline monitoring period and identified as Site 1. This site is located just west of the western tract boundary. The UTM coordinates of the site are 148, 500E; 227, 034N. The monitoring instruments are housed in an environmentally controlled shelter and draw a sample of the ambient air from a common glass manifold which has an intake 4 m above the ground. Each monitoring instrument is connected to a strip chart recorder which continuously records the instrument output signal. In addition, an automatic data acquisition system scans each parameter being measured once each three minutes and computes a running 15-minute average. The current average value is recorded on magnetic tape at the end of each quarter hour. Hourly averages are automatically computed from the 15-minute averages when the data are reduced. The hourly average value of a parameter is centered on the hour (i.e., the data point computed at 0200 hours is the average that was obtained between 0130 and 0230). Data taken during the MDP program are presented in the appendix.

A. Sulfur Dioxide

Sulfur dioxide is produced principally by the combustion of sulfur bearing fossil fuels. At the present time the amount of combustion that takes place in the tract region is very low and it is to be expected that there would be very little sulfur dioxide in the ambient air. However, with tract development some fuel combustion will be required and sulfur dioxide emissions may occur.

1. Objectives

The objective of monitoring for sulfur dioxide is to establish the ambient air concentration prior to significant tract development. The existing sulfur dioxide levels and their associated environmental effects can be compared to future environmental changes that may be related to any increase in the concentration of sulfur dioxide in the ambient air in the tract region.

2. Methods

Sulfur dioxide monitoring is conducted with an automated chromatograph that analyzes a sample of ambient air each three minutes. The instrument has a threshold of detection of approximately 20 parts per billion of sulfur dioxide. Supplementary measurements of ambient air concentration of sulfur were made using the pararosanaline wet chemical technique.

3. Results and Discussion

The continuous measurement instrument provided concentration readings that were below the reliable threshold of detection for the entire period. The wet chemical measurements were made when the continuous instrumentation indicated a concentration below the threshold of detection. The wet chemical method results provided a value of four parts per billion average for a four-hour sample.

B. Hydrogen Sulfide

Hydrogen sulfide in the ambient air is generally the result of emissions from the decay of sulfur containing organic materials, release from underground oil, gas or water deposits, or emissions as a result of volcanic action. There are no air quality standards for ambient air concentrations of hydrogen sulfide in the tract area. However, the gas is toxic, and at low concentrations represents a nuisance because of its odor.

1. Objectives

The objective of monitoring hydrogen sulfide concentration in the ambient air on the tract is to establish the normal background value. Tract development which will involve recovery of sulfur-bearing organics may involve the release of hydrogen sulfide into the ambient air. Environmental impacts of this constituent in the future may be compared to pre-development effects, if any.

2. Methods

Hydrogen sulfide is measured by an automated gas chromatograph that samples the ambient air once every three minutes. Additional measurements of the hydrogen sulfide concentration have been made using a cadmium sulfate wet chemical detection method. The automated instrument has a reliable threshold of detection of 20 parts per billion. The wet chemical method can detect lower levels when long sampling periods are used.

3. Results and Discussion

The concentration of hydrogen sulfide in the tract area was below the threshold of detection of the instrumentation for the entire data period. The wet chemical samples that were acquired produced a concentration measurement of three parts per billion. The nominal global background value for the concentration of hydrogen sulfide is 2- to 2.5-parts per billion. The wet chemical samples were of four hours duration.

A review of the baseline and interim data for hydrogen sulfide shows that whenever hydrogen sulfide was detected, it was always accompanied by a similar increase in atmospheric sulfur dioxide. The only significant events were noted on two consecutive days when both of these constituents were detected at low levels and exhibited a diurnal cycle. There appear to be no local sources of hydrogen sulfide. The dryness of the climate does not promote the rapid decay of vegetation under conditions that normally generate hydrogen sulfide.

C. Nitrogen Oxides

The nitrogen oxides are produced generally by high temperature combustion which fixes atmospheric nitrogen. In urban areas nitrogen oxides are produced by automotive exhaust. In the tract area there is very little automotive exhaust or combustion that would result in the generation of nitrogen oxides and it is to be expected that no significant concentration of these constituents would be found. An air quality standard has been established for nitrogen dioxide. The standard limits the annual average concentration.

1. Objectives

Nitrogen oxides are monitored to estabish the existing natural background levels prior to the initiation of tract development and operation. Tract operations will involve substantial combustion with the generation of nitrogen oxides. The emission of nitrogen oxide in the presence of sunlight and hydrocarbons is proposed as the mechanism of smog production. Nitrogen oxide data may prove useful in correlating potential visibility changes with pollutant concentration.

2. Methods

Nitrogen oxides are measured by instrumentation that detects the chemiluminescent reaction between nitrogen oxide and ozone. The nitrogen oxide is detected directly, and the other oxides of nitrogen, principally nitrogen dioxide, are catalytically converted to nitrogen oxide for detection. The instrument provides data values for both nitrogen oxides and nitric oxide. The difference between the two is assumed to be nitrogen dioxide. The reliable threshold of detection of the instrumentation is 10 parts per billion nitrogen dioxide.

3. Results and Discussion

During the monitoring period there were no hours that registered a concentration of nitrogen oxides greater than the reliable instrument threshold. A review of the two-year baseline data set and the interim data shows that the average value of concentration was determined to be less than the instrument threshold for the entire period of two and three quarters years. Occasionally there is a small concentration indicated for a period of five minutes or less that is a result of a vehicle visiting the site when wind conditions are suitable for carrying the vehicle exhaust toward the air sampling manifold intake.

D. Carbon Monoxide

Carbon monoxide results from the incomplete oxidation of carbon during combustion. A national ambient air quality standard for carbon monoxide has been established.

1. Objectives

Carbon monoxide is monitored to establish the ambient air concentration of this constituent prior to tract development activities. Vehicular use and fuel combustion during tract development may result in the emission of carbon monoxide in the tract area.

2. Methods

Carbon monoxide in the ambient air is monitored by an instrument which detects by the infra-red radiation absorbing properties of this constituent. The reliable threshold of detection of the instrument is one part per million.

3. Results and Discussion

The average concentration of carbon monoxide in the ambient air during the monitoring period was below the reliable threshold of the instrument. There were no hours during the period when a detectable level was recorded. A review of the baseline data set shows the average concentration to be less than the threshold of the instrumentation used to detect this constituent for the two and three quarters years of monitoring.

E. Hydrocarbons

Hydrocarbons in the ambient air may originate from a variety of sources:

- Natural methane
- Evaporated solvents and volatile liquids
- Unburned fractions of organic fuels
- Vegetation
- Etc.

A national ambient air quality standard for the concentration of non-methane hydrocarbons in the ambient air has been established for use in planning air

pollution abatement programs where non-methane hydrocarbons are precursors for photochemical smog.

1. Objectives

Methane and total hydrocarbon monitoring has been conducted to determine the concentration of these constituents in the ambient air prior to major tract development activities.

2. Methods

Methane and total hydrocarbon monitoring is conducted with a gas chromatograph instrument that detects constituents with a flame ionization device that measures the carbon content of the sample. The instrument is only specific for methane. The reliable threshold of detection for methane and total hydrocarbon is 20 parts per billion. The non-methane hydrocarbon concentration is obtained by subtracting the methane value from the total hydrocarbon value. The uncertainty in each of these parameters is such that there is the potential for considerable error in the difference value.

3. Results and Discussion

The methane concentration in the ambient air fluctuates very little from a nominal value of 1.4 ppm. The maximum total hydrocarbon value recorded during the monitoring period was 2.6 ppm. The source of the non-methane hydrocarbon has not been identified. Due to the potential uncertainties in the non-methane hydrocarbon calculation, as performed by the reference instrumental method, values in excess of the 6 to 9 a.m. limits referenced in the air quality "standard" are not reported as violations because the "standard" is actually only a guideline established by EPA.

F. Ozone

Ozone concentration is taken as a measure of total oxidants in the ambient air. In urban areas ozone is thought to be the result of the interaction of nitrogen

oxides and sunlight in a complex photochemical reaction initiated by automobile exhaust emissions. A national ambient air quality standard has been established for the concentration of total oxidants in the ambient air. Ozone is a powerful oxidizer and can damage vegetation and materials as well as produce deleterious health effects in man and animals.

1. Objectives

Ozone monitoring is conducted to establish the ambient air concentration of this constituent prior to tract development and operation. The potential emission of nitrogen oxides coupled with hydrocarbons and strong sunlight may produce photochemical reactions in the future in the tract area.

2. Methods

Ozone is detected in a sample of the ambient air by reacting the sample with ethylene gas to cause a chemiluminescent gas phase reaction between the ozone and the ethylene. The method is specific for ozone and has a threshold of detection of 10 parts per billion. Supplementary wet chemical tests for total oxidants were conducted using the neutral potassium iodide method.

3. Results and Discussion

The behavior of the ozone concentration in the ambient air in the tract area differs from its behavior in urban areas. First, the necessary ingredients for conventional ozone formation are present in very small quantities yet the concentration is appreciable in that it is comparable to an urban area with large amounts of automotive exhaust emissions. Second, in urban areas the ambient ozone concentration disappears during the night whereas in the tract area the nighttime concentration remains at appreciable levels. There is a strong diurnal variation, particularly at site 3 located in Corral Gulch, in the ambient air concentration that is related to sunrise and sunset. In an urban area there is a time delay in ozone formation which results in a peak daily concentration in the early afternoon. In the tract area the peak values are generally reached by 10 a.m. local time.

The wet chemical tests provided measurements of total oxidants that were 15 to 45 percent higher than the values determined by the chemiluminescent technique. Results similar to this have been obtained elsewhere in comparative tests between the two methods of detection.

Most of the ozone concentration readings were within the range of 0.03 and 0.07 ppm during the monitoring period. The maximum value recorded was 0.081 ppm, which exceeds the 0.08 ppm Federal 1 hour standard for photochemical oxidants. Only one such violation of the photochemical standard was recorded during this data collection period. This Federal standard has also been exceeded at other rural sites. This primary standard is currently under review by EPA.

G. Particulates

National Air Quality Standards have been established for total suspended particulate matter in the ambient air. This is a general standard that does not differentiate between national and anthropogenic sources of particulate matter. Materials handling and transport, natural wind erosion of the ground surface, the products of combustion, vegetation pollination, and a variety of other sources contribute to the total particulate load in the atmosphere.

1. Objectives

The objective of atmospheric particulate monitoring is to establish the natural background concentration that exists in the pre-development phase of tract operations.

2. Methods

The total suspended particulate load in the ambient air is determined by the federal reference method utilizing high volume sampling. During the monitoring period total suspended particulate measurement was reduced to a once every sixth day schedule because of the low level of tract activity.

3. Results and Discussion

The geometric mean concentration of total suspended particulate measured at ground level of Site 1 during the monitoring period was 16.7$\mu g/m^3$. The maximum value was 25.3$\mu g/m^3$.

Particulate measurements were also made at Site 1 from an elevated sampler location. The geometric mean of the measurements was 10.1$\mu g/m^3$, the highest value obtained was 25.0$\mu g/m^3$. The highest values from each sampler were obtained on the same day.

Particulate sampling at Site 3, yielded data with a geometric mean concentration of 28.3$\mu g/m^3$ with a highest value of 60.7$\mu g/m^3$. This site is exposed to particulate tnat is generated by vehicular traffic on the tract access roadway.

The particulate levels measured at site one are comparable to the levels measured during the interim monitoring period.

2'.2 METEOROLOGY

Meteorology parameters are monitored to provide information on the general climate of the tract area and to provide a basis for estimating the potential impact of emissions that will result from tract development and operation.

A. Ambient Wind and Air Temperature

1. Objective

The wind speed and direction influence the dispersion of emissions into the atmosphere that may occur as a result of tract development and operation. Measurement of the frequency of occurrence of wind direction and wind speed classes can be used in interpreting air quality data.

2. Methods

Wind speed and direction were measured by instruments mounted on a 60-m tower at Site 1. Data were gathered at the 10-m and 60-m levels. Air temperature was measured at the 10-m level.

3. Results and Discussion

The prevailing wind direction at both levels was from the southwest quadrant approximately 40 percent of the time. The lowest frequency of winds were from the southeast quadrant, approximately four percent of the time. Wind roses for the data period are included in the appendix.

B. Precipitation

1. Objective

Precipitation is recorded to provide data on the scavenging effects of rain and snowfall on air quality. The moisture content of the ground surface may also influence wind erosion.

2. Methods

Precipitation is monitored at Site 1 with several gauges. One is a tipping bucket gauge, one is a heated total precipitation gauge, and one is a manually operated wedge gauge. The wedge gauge was installed to provide data from a location further removed from the instrument shelter. The two automatic gauges provide results which do not agree closely even though they are located about 10 feet apart. It is suspected that there is some influence due to the location of the shelter that partially shields one or both of the automatic gauges from the wind flow that accompanies most shower type rainfall.

3. Results and Discussion

Precipitation data from the several measuring methods are included in the data

appendix. These data still show a difference between methods that appears to be unreasonable. The total precipitation recorded was substantially increased over measurements made during the biennial baseline monitoring period.

C. Other Meteorological Parameters

Insolation and relative humidity are measured routinely at the Site 1 location.

1. Objective

Insolation is monitored to acquire a data base useful in interpreting air quality data. Relative humidity data are useful in evaluating potential cooling system alternatives.

2. Methods

Insolation is measured with a pyrometer mounted at ground level. Relative humidity is measured with a plastic sensor mounted at the 30-m level on the 60-m tower.

3. Results and Discussion

The insolation data are reported in the appendix. The majority of the days during the monitoring period were clear with maximum insolation values greater than 0.8 Langley. The relative humidity varied from a low of 11 percent to a high of 91 percent. The data from this reporting period are comparable to the data reported from the biennial baseline period.

Plans are currently being made to augment the relative humidity data with instrumentation designed to measure dewpoint. This instrumentation has been received and will be placed on line during the winter quarter. Data available from this instrument will provide additional information for interpreting the air quality data.

D. Visibility

The Tract C-a visibility program consists of two discrete parts--(1) a cooperative basin-wide photometric visibility study, and (2) a site specific observer-based visibility estimate program. The basin-wide program is a continuation of the baseline program. It will be conducted biannually at the visibility shelter in Piceance Creek basin, midway between Tracts C-a and C-b. The site specific visibility estimate program is an expansion of similar baseline studdies. Visibility estimates are made at Site 1 once each week.

For the purposes of this report, visual range is used within a narrow sense and visibility is used in a broader context. Visual range is defined in the following way: As an object is moved through the atmosphere toward the horizon sky, the contrast between the object and the sky decreases. At some distance the contrast becomes too small to be detected by the observer, and the object vanishes. The distance from the observer to the object at the vanishing point is the visual range. The term visual range is used in this report when referring to a maximum distance of sight along a single path length.

Visual range can vary in time and by direction. It is common for a view to the west to differ significantly from a view to the south when comparing concurrent measurements of visual range. For a fixed direction, the visual range may change throughout the day. Such directional and time dependences can be detected by the human eye. Thus, specific situations exist for each direction at a certain time. At any given time there is a more general or synoptic situation created by the directional dependence of visual range. Finally, there is the general long-term climatological situation that exists because of changes in visual range over all directions over a long period of time.

Visibility is a more general term, descriptive of the basic situations discussed above. As such it definitely has the connotation of a general state of clarity of the air. However, it does not represent an entirely subjective concept because of its connection with a given quantifiable set of values for visual range. Visibility is used as an areal descriptor. It refers to an average of all directional visual range observations over specified periods of

time and is also used in a qualitative sense to describe the clarity of the air as evaluated from overviews of visual range data taken from the visibility shelter. Visibility estimates taken from Site 1 are descriptive values.

1. Objectives

Visibility studies were conducted during the baseline period to document visibility in the area prior to disturbance. The objectives of the MDP visibility monitoring program will be to supplement baseline data, to compare visibility during initial stages of development with baseline conditions, to compare visibility with concurrent meteorological conditions, and to evaluate effects of development on long-term trends and basin-wide visibility.

2. Methods

a. Data collection techniques - The basin-wide visibility data will be collected from a shelter eight miles southwest of Piceance Creek on a ridge between Hunter Creek and Dry Gulch. The legal description of the shelter location is: T3SR97W S19SW/4SW/4.

Several objects, such as mountains or ridges, will be photographed in each of four views which scan the horizon from the north-northwest to the east-northwest. Black and white photographs will be taken seven times a day every sixth with a 35 mm camera attached to an 800 mm refractive lens. At least 10 successful sampling days will be completed each season. In addition, 35 mm color slides will be concurrently taken with a normal focal-length lens to record the sky and weather conditions in each view during the three-month sampling period. Photographs will be taken at 0830, 0930, 1030, 1130, 1300, 1400, and 1500 hours MST during the scheduled photography period. Care will be exercised to properly record sampling dates on exposed film and to ensure proper alignment of photographic equipment during photography. Pertinent weather conditions, e.g., rain, fog, cloud cover, and other essential information will be noted in a site log at the shelter.

Basin-wide visibility data will be collected biannually beginning in Spring 1978. Two sampling periods will be scheduled each year, one in the Spring, the other in the Fall. Data will be collected every sixth day during a three-month period to establish at least 10 successful sampling days.

Site specific visibility estimates are made at Site 1 once each week by the site technician. Notations of general and local conditions (e.g., fog, dust) are made to allow evaluation of the causes of reduced visibility. Visibility estimates are recorded on the site log.

b. Data reduction - Black and white film exposed at the visibility shelter will be processed under carefully controlled conditions at the Dames and Moore laboratory. Color slides will be developed by commercial processors.

Prior to development, each roll of black and white film will be exposed to a calibrated series of 11 different light intensities in a Kodak Process Control Sensitometer, Model 101. After completion of the development, the densities of each of the 11 exposed areas of film will be obtained with a MacBeth TD Densitometer. These density values will be plotted against the logarithm of the exposure to provide a characteristic curve for the particular roll of film. This curve will be used to determine the relationship between image density and exposure.

Steffans' (1949) method for computing visual range will be used to calculate visual range for the basin. This method assumes that the presence of an image in any photographic negative is due to contrasts in light reflected by the several objects in the picture. This light enters the camera and sensitizes the film. The image on the film is created by an exposure, E, of the film proportonal to the intensity of light, I, from the object. The ratio of light intensities from two objects in the same frame can be obtained from the measured densities of the two images and the characteristic curve. For example, if D_1 and D_2 are the image densities of two objects in the same frame the characteristic curve can be used to determine values for log E_1 and log E_2 corresponding to the image densities D_1 and D_2. The ratio of light intensities

I_1 and I_2 from the two objects is:

$$I_1/I_2 = E_1/E_2$$

Steffans' method of computing visual range includes choosing the horizon sky as one of the objects. This may be denoted by replacing the subscript "2" with "∞". Object 1 at a distance x from the camera produces an image of density D_x. The horizon produces an image of density D_∞. The ratio of light intensities I_x/I_∞ is determined in the manner described above. The visual range, VR, is computed from the formula:

$$VR = Mx/\ln(1-I_x/I_\infty)$$

where M is related to the ability of the eye to detect contrast. It has been found that the "average" eye is capable of detecting contrasts no less than two percent. For such an average eye, M has the numerical value of 3.912.

The above equation for visual range implies that the object is black. In practice the objects are dark, but not black. However, the equations can be modified to account for the non-zero reflectance of the objects. Each object will be examined from the air to estimate the type and amount of vegetative cover from which an albedo (reflectance) could be determined. Albedoes of 0.15 typically were used during the warmer months of the year during baseline visibility studies when no accumulations of snow existed.

The observer-based visibility estimates at Site 1 are qualitative. Visibility to known reference points are expressed in miles.

3. Results and Discussion

The first cooperative basin-wide study is scheduled for Spring 1978. Results of this study will be reported in RBOSP MDP Monitoring Report 3.

Observer-based visibility studies were initiated at Site 1 in December 1977, after the end of the present reporting period. Results of this study will be presented in RBOSP MDP Monitoring Report 2.

E. Noise

Regulations for the control of noise are oriented toward the protection of exposed personnel since there is little literature on the impact of noise on ecological systems. However, data gathered for the health and safety program will provide information necessary for assessing effects of noise on wildlife.

1. Objectives

The objectives of the noise studies will be to identify increases in environmental noise levels due to development, demonstrate compliance with regulations regarding noise, and to assess the general effects of increased noise levels on wildlife.

2. Methods

To accomplish the above stated objectives, ambient noise levels will be measured on Tract C-a and vicinity during the Modular Development Phase. RBOSP is currently preparing a scope of work which will provide details of the noise program. The program will be designed to comply with American National Institute Standard SI-41971 and in consideration of comments made by the Area Oil Shale Supervisor (AOSS).

3. Results and Discussion

The noise study has not yet been initiated. Details of the noise program will be finalized during the winter quarter, and the studies will be initiated during that quarter. Results of this program will be included in subsequent monitoring reports.

F. Air Quality Data Summaries

The data summaries incorporated in the Appendices were prepared from data acquired by automatic monitoring instrumentation located on tract C-a. The data are recorded on magnetic tape and analog strip chart recorders. Data from both recording systems were used to assemble the summaries. Correction factors were applied to several parameters. The factors were determined by calibration of the detection instruments in the field. The threshold of detection of each instrument was established by the manufacturer's specifications and where the recorded concentration of any pollutant was below the reliable threshold of detection, a number equal to one half of the threshold value was substituted for the data point. This procedure is adopted from the EPA Quality Assurance Handbook, Air Pollution Measurement, Vol. 1. For sulfur dioxide, hydrogen sulfide, nitrogen oxides and carbon monoxide this applied to data acquired through the entire period.

Each instrument was tested at least once a week by inserting a zero pollutant concentration and at least one upscale concentration. These tests provided data on instrument drift and ensured that the instrument would respond to a sensible level of pollutant concentration in the ambient air.

Span calibrations were conducted by supplying the instrument with a known concentration of test gas. The concentrations of the test gas were determined either by vendor certification or by wet chemical tests using applicable Federal Reference methods. The applicability of the current Federal Reference Method for ozone using the Neutral Buffered Potassium Iodide technique has been shown to introduce a positive bias and questionable reproducibility. The ozone data were adjusted on the basis that the NBKI tests conducted on site are biased by 28 percent when compared to the gas phase titration technique. This comparison was made during a site audit conducted under the Western Energy Quality Assurance Program.

Calibration of the sulfur dioxide and nitrogen oxides instruments were conducted with permeation tube sources and the concentrations measured with the West Gaeke and modified Saltzman methods, respectively. Calibrations were attempted at levels near those expected to be measured in the ambient air.

At these concentrations, the calibration data provides poor reproducibility. There is no practical effect of this factor on the data since the instruments did not detect these pollutants at concentrations greater than the threshold of detection. Occasionally, the instruments did respond for a few minutes when a vehicle was driven to the monitoring site by the site technician, indicating that the instruments were functioning properly.

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SECTION 3

TERRESTRIAL STUDIES

The Terrestrial Studies MDP Monitoring Program is designed to detect and evaluate those impacts affecting the soil, vegetation or faunal components of the terrestrial ecosystem on or near RBOSC Tract C-a. An intensive two-year terrestrial program was conducted from October 1974 through September 1976 to characterize the biotic conditions existing prior to MDP development. Specific terrestrial baseline studies included soils, vegetation, range and browse, small mammals, large mammals, mammalian predators, reptiles and amphibians, avifauna, domestic livestock, and terrestrial invertebrates.

The Interim Monitoring Program conducted from September 1, 1976 through August 31, 1977 included range and browse, small mammal, large mammal, and avifauna studies. These studies were conducted to provide continuity with the baseline studies.

The MDP Monitoring Program (Table 3-1) includes studies of soil trace metals and conductivity, distribution of vegetation types, range production, browse condition and utilization, mule deer, feral horses, and threatened and endangered species. These parameters were selected because of their importance to the ecosystem, their special status, or their likelihood to be adversely affected by impacts. Some biotic groups were not included in the monitoring program because they are relatively unimportant in the Tract C-a ecological system (e.g., reptiles and amphibians) or because quantification of abundance and distribution is not possible (e.g., terrestrial invertebrates).

The terrestrial monitoring program is based on an assessment of current knowledge of MDP mining operations. Because this is a prototype operation, new information may become available which requires a modification of the outlined program. Therefore, this monitoring program should be viewed as a flexible one which may change as engineering design is refined and as additional ecological data are obtained.

3.1 SOILS

During the RBOSC baseline studies,an extensive soils program was conducted on Tract C-a and 84 Mesa. During these studies, soils were described and mapped

Table 3-1. Terrestrial Studies Monitoring Schedule

Parameter	Location	Start Date	Frequency
Trace Metals (Collection & Storage of soils & vegetation samples)	See Figure 3-1	Aug. 1981	Annually
Soil Conductivity Studies	See Figure 3-2	Aug. 1981	Annually
Vegetation Mapping	Tract C-a & 5-mile Perimeter	May 1978	Annually
Range Productivity & Utilization	See Figure 3-3	April 1978 (establish plots)	Annually (in Sept.)
Browse Condition & Utilization	See Figure 3-3	May 1978	Annually
Mule Deer Density Studies	See Figure 3-4	Sept. 1977	Semi-annually (May, Sept.)
Feral Horse Abundance	Tract C-a & 3-mile Perimeter	Jan. 1978	Annually
Threatened & Endangered Species	Tract C-a & 3-mile Perimeter	Nov. 1978	Opportunistic

and the chemical and physical traits of these soils were determined. The soils of Tract C-a and adjacent areas are typical of semi-arid regions. Saline and sodic materials were found in the study area and these soil properties are reflected by the presence of salt-tolerant vegetation, e.g., greasewood and saltbush, in the area. Macro- and micronutrients were generally within the ranges expected; trace element concentrations were within ranges considered normal for surface soils in the West.

A. Trace Metals

Gaseous and particulate emissions containing toxic trace elements could be released from the MDP and Commercial Phase underground and surface retorts. Precautions will be taken during the MDP and Commercial Phases to prevent such emissions in accordance with appropriate federal and state air pollution regulations. The following program is designed to detect any accumulation of trace metals in the soils and vegetation should trace metal emissions occur.

1. Objectives

The objective of the trace metal study is to collect soil and vegetation samples which will be stored for future trace metal analysis. If source emission monitoring indicates that trace metal emissions are occurring, these stored samples will be analyzed to determine trace metal content. Although projected gaseous and particulate emissions are not expected to contain trace metals, source emission monitoring is designed to determine if trace metals do occur in emissions. Soil samples are collected concurrently with the air quality monitoring program.

2. Methods

Figure 3-1 indicates that particulate concentrations are projected to increase with distance from the tract in NE, NW, and SW directions. The maximum concentration of particulates (3.0 $\mu g/m^3$) is expected to occur three miles southwest of the tract. Four sampling sites (1.5 x 1.5 mile area) are located three miles from each corner of the tract (Figure 3-1). Four sampling loca-

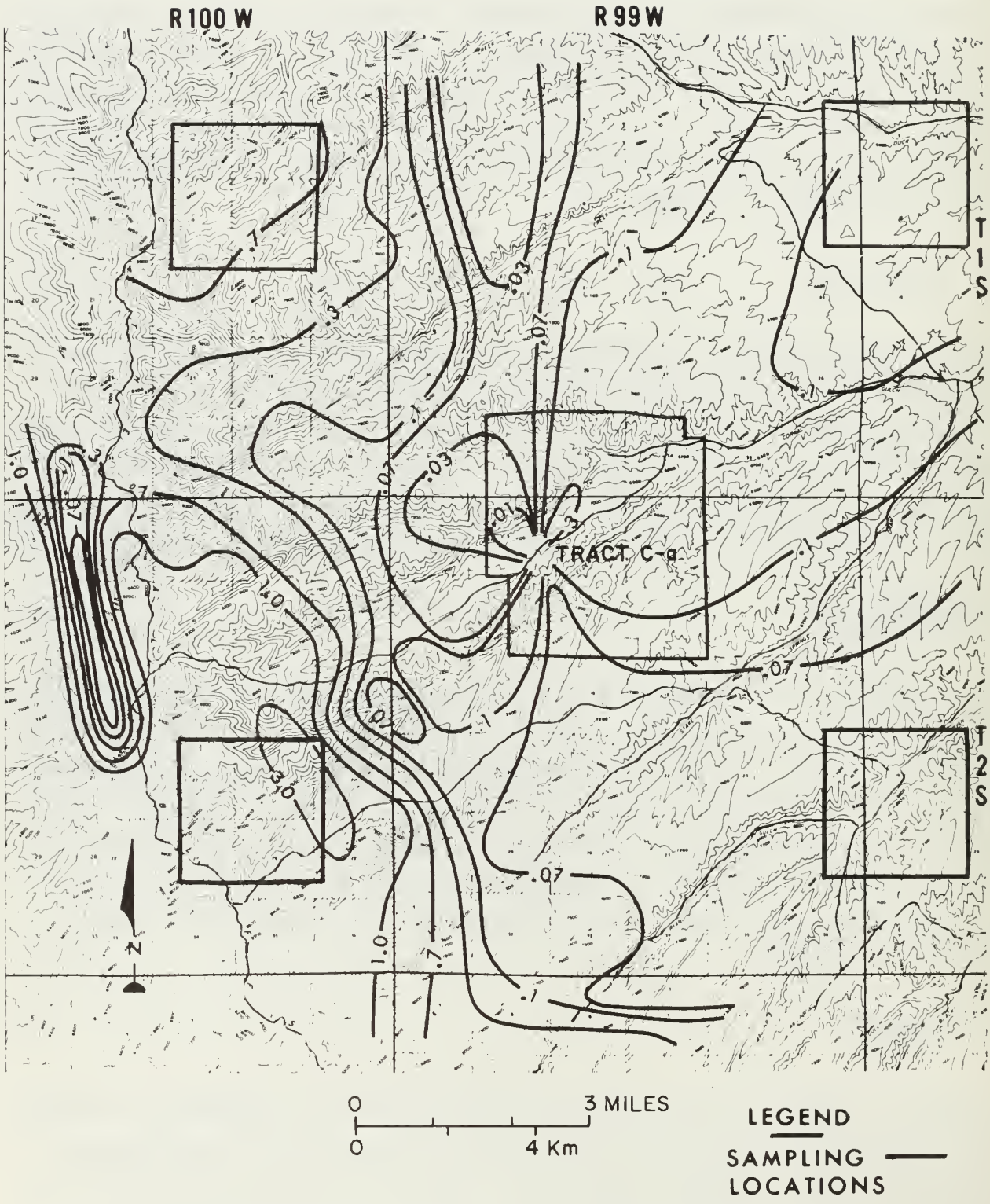


Figure 3-1. Location of Soil Monitoring Sites Based on Particulate Dispersion ($\mu g/m^3$) During the Commercial Phase.

tions should insure detection of particulate emissions if deviations from the predicted model occur. Ten soil samples will be collected at each site in 1981, the year before commercial operations begin, and annually thereafter. Samples will be collected during August from the surface soils (0-10 cm) of each site. Five composite vegetation samples each, of sagebrush and a metal-concentrating plant (e.g., Astragalus) will be collected at each site from the current year's growth.

Soil and vegetation samples will be stored until sample disposal is authorized by AOSO or until significant levels of trace metals are detected by source emission monitoring. If significant levels are detected, soil and vegetation samples will be analyzed for those elements shown to be in the air emissions (e.g., Sb, As, B, Cd, F, Hg, Se, Mo, and V).

3. Results

No results are available. The first soil sample collection is scheduled in August of 1981 (Table 3-1).

B. Conductivity

During the Commercial Phase, cooling towers will be operated in conjunction with surface retorting. Salt drift will result from this operation. An evaluation was made of the present conductivity levels in the Tract C-a soils during the baseline studies; saline soils were present.

1. Objectives

Levels of salt drift from the cooling towers are projected to be low (Figure 3-2). Nevertheless, the soil conductivity studies are designed to detect any significant changes in soil salinity or conductivity levels which might result from an accumulation of salt drift from the towers. These data will be evaluated to determine if any such soil salinity changes are detrimental to plant growth.

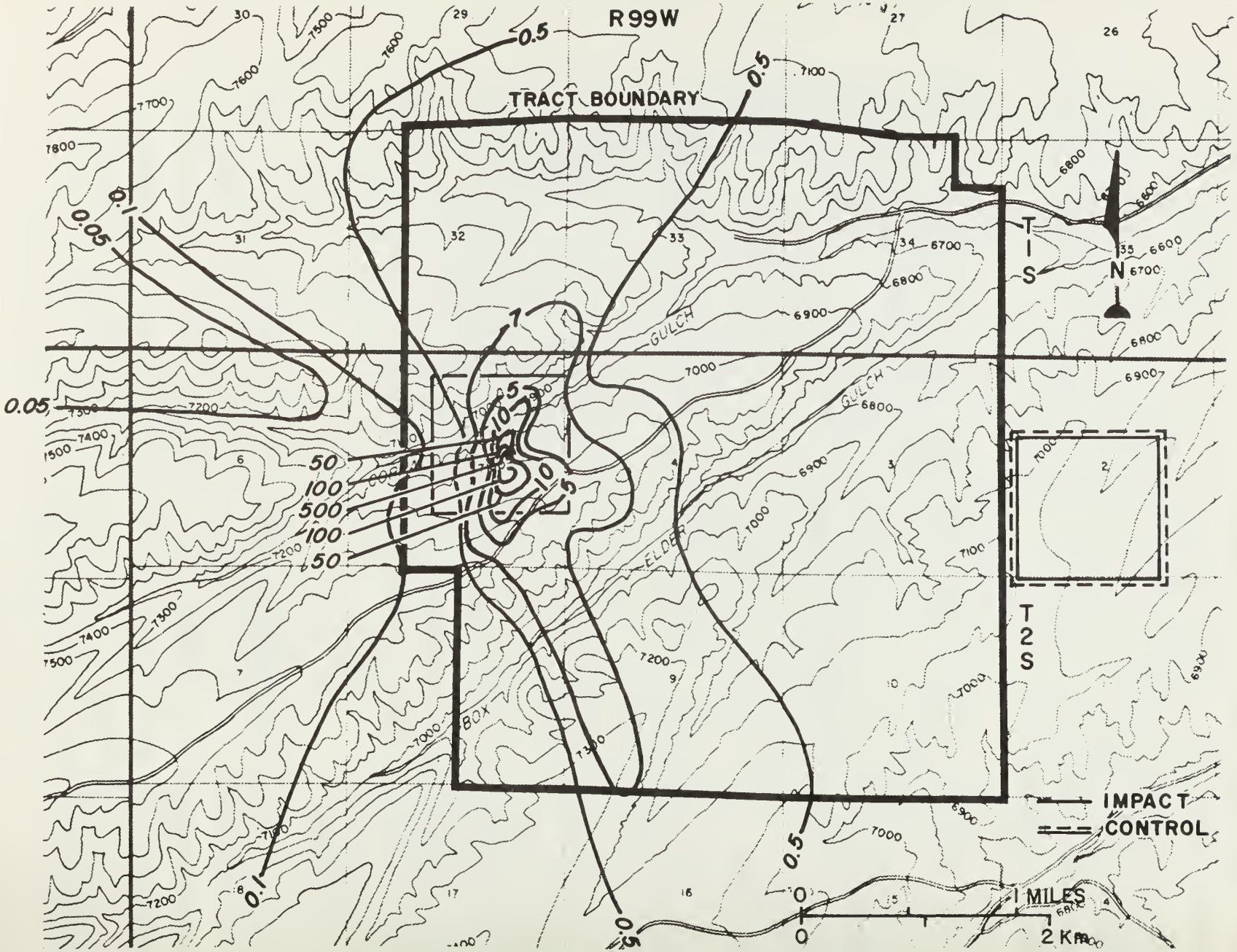


Figure 3-2. Location of Soil Monitoring Sites Based on Salt Drift Dispersion Pattern

2. Methods

Modeling efforts indicate that the maximum concentrations of salt drift are expected to occur immediately adjacent to the cooling tower (Figure 3-2). The areas of maximum deposition are small in comparison to particulate dispersion patterns. In addition, large deviations from the projected dispersion pattern are not expected because of the large size of the salt droplets. Therefore, specific control and impact sites (0.5 x 0.5 mile) have been selected in the expected maximum and minimum salt deposition areas (Figure 3-2).

The control site was selected in an area where soils (Rentsac and Rentsac-Piceance) are similar to those in the impact area. Baseline studies indicate that both soil series have low soil conductivities (Rentsac = 0.42 mmhos/cm based on a sample to extract ratio of 1:2). Therefore if appreciable salt deposition occurs, detection of a change in soil conductivity should be possible.

Twenty soil samples will be collected randomly from the Rentsac or Rentsac-Piceance soils in each of the impact and control areas. Samples will be collected in August beginning in 1981, the year prior to commercial development. Soil samples will be collected from the surface soils (0 to 10 cm) of each site. These samples will be analyzed by a commercial laboratory to determine electrical conductivity.

The soil material remaining after analysis will be stored. If these tests reveal that a significant change in electrical conductivity has occurred after operation began, the stored samples will be analyzed to identify the elements contributing to the increased conductivity, e.g., chloride, gypsum, etc.

3. Results

No results are available. The first soil sample collection is scheduled in August of 1981 (Table 3-1).

3.2 VEGETATION, RANGE, and BROWSE

Tract C-a and the surrounding five-mile area studied during the baseline program contains eight major vegetation types (RBOSP 1977). The baseline vegetation studies were conducted to identify the plant species present, to determine the structure and composition of the vegetation, and to map the distribution of the major vegetation types in the study area. These investigations included intensive phytosociological sampling (using line-transects and areal plots), aerial photography, and qualitative evaluations. The phytosociological studies were discontinued during the Interim Monitoring Program because sufficient data were available to characterize the vegetation. During the MDP the local distribution of the vegetation will be monitored annually by aerial photography.

The capacity of the vegetation for supporting animal life was determined during baseline studies by conducting range and browse studies. Range, browse, and soil condition and trend studies were conducted to determine the current status of these elements in relation to the potential. Range production and utilization studies were conducted to obtain an estimate of the carrying capacity of the area for domestic animals. Browse condition and utilization studies (Cole 1963) were conducted to define the condition of the important browse species and their degree of utilization by wildlife species.

The range production and utilization studies and browse condition and utilization studies were continued during the Interim Monitoring Program because of the importance of range and browse conditions to wildlife and to obtain additional data regarding the relationship of climate and browse and range conditions. Similar range and browse studies will be conducted during the MDP to detect any change in condition or wildlife use resulting from MDP activities.

A. Vegetation

1. Objectives

Construction and operation at Tract C-a may affect the local distribution of

vegetation types as a result of dewatering and reinjection. The vegetation study is designed to monitor the distribution of vegetation on Tract C-a and adjacent areas to determine large-scale changes resulting from MDP development.

2. Methods

Color infrared aerial photography (1 inch = 2,000 feet scale) will be taken annually, beginning in 1978 (Table 3-1). The photographed area includes Tract C-a and the area within a five-mile radius. The RBOSC vegetation map (RBOSP 1977) will be compared annually to previously taken aerial photographs to determine any changes in the distribution of vegetation types. If changes are detected, the vegetation map will be modified to reflect them. The color infrared photography will also be examined to determine major vegetation stress conditions. If such stress conditions are detected, an additional sampling program will be initiated upon approval by AOSO to determine the extent and cause of damage. This program is designed to provide qualitative information on abundance and distribution of the predominant vegetation types in the study area. Vegetation distribution data are presented on a vegetation map which is used as the basis for calculating the acreage of each vegetation type in the study area.

3. Results

No results are available since this program is scheduled to begin in May of 1978 (Table 3-1).

B. Range

1. Objectives

MDP activities on Tract C-a may affect the range conditions on and near tract. These studies are designed to provide information on vegetative production which can be used to compare range productivity before and during modular development. Because the potential impacts are projected to be localized, the range studies focus on areas on Tract C-a that are adjacent to MDP activities

and that were previously used for grazing.

2. Methods

The range sampling sites were selected at random in mixed brush, pinyon-juniper, and sagebrush in the same general location as the browse transects. The distribution of the interim range transects (mixed brush - 5, pinyon-juniper - 10, sagebrush - 15) will be modified to establish 10 transects in each vegetation type. The tentative locations of the 30 range sampling transects are presented in Figure 3-3. Because Transects 5, 11, and 12 are located in close proximity to the MDP activities, these transects may be relocated to adjacent areas.

Forage is measured annually at the end of the growing season (September) by the double sampling method (USDA Region 2 1970). Five caged plots (9.6 sq ft in size), and five unprotected plots (permanently marked) are located at 10 m intervals along each sample transect. The plots will be permanently established in April of the first year, and the five caged plots will be moved to new locations each April-May. Sampling is done with a 9.6 sq ft sampling loop on each of five unprotected plots. An ocular estimate is made of production (weight to the nearest gram) of the dominant grass and forb species (species making up 90 percent of the individuals) within the loop. The five protected plots are estimated in the same manner. Each species within the protected plots is then clipped, bagged seperately, weighed green and the weights are recorded. Species providing less than one percent of the biomass are recorded as being present, but are not weighed. Correction factors are calculated from the estimated green weights and actual green weights of the clipped plots. These correction factors are used to correct all estimated values.

$$\text{Correction Factor} = \frac{\text{Actual Green Weight}}{\text{Estimated Green Weight}} \times 100$$

When the clipped samples have air dried for approximately 30 days or more, they are re-weighed to obtain moisture percentages. All corrected estimates are then computed, using these moisture percentages, to give air-dry forage

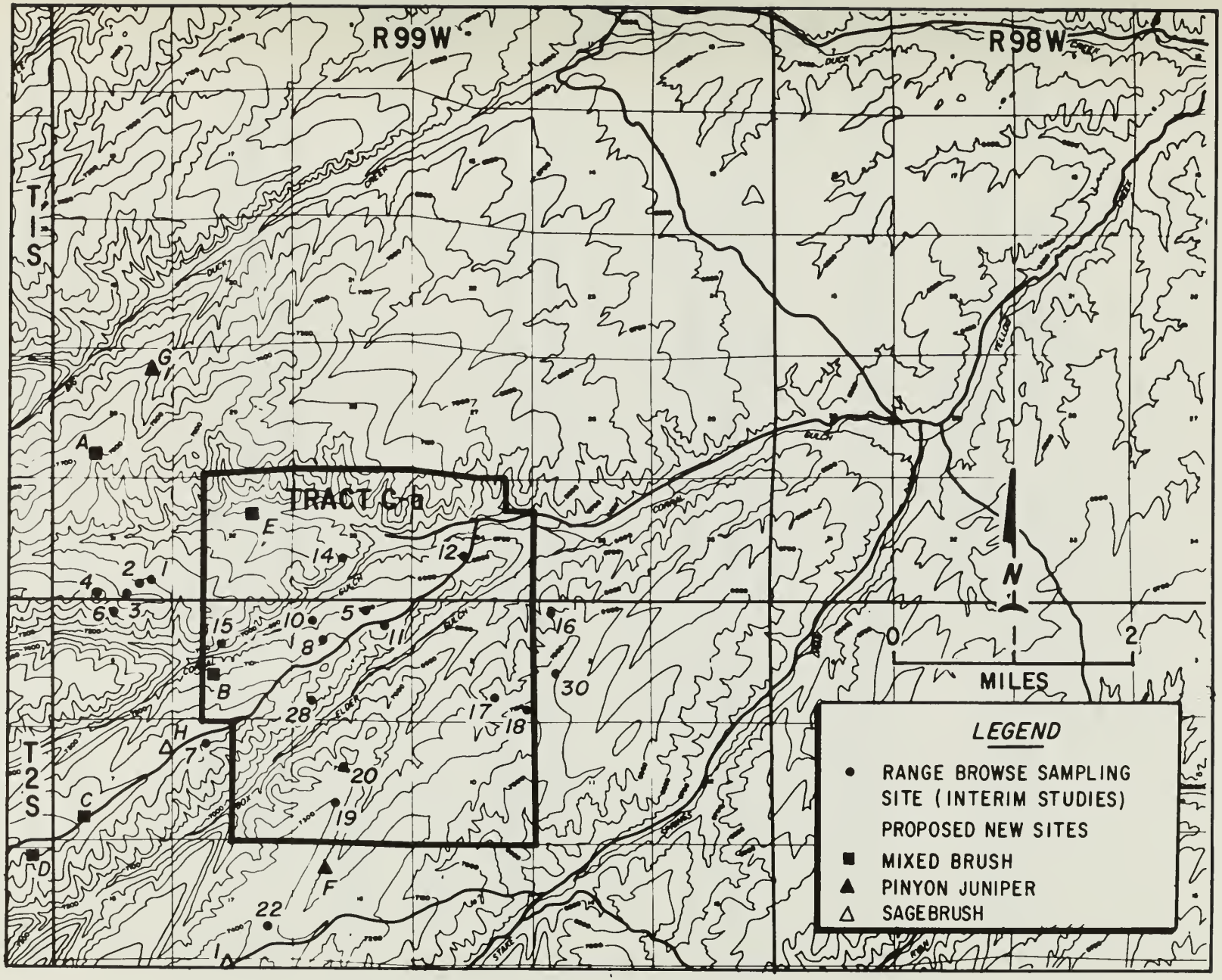


Figure 3-3. Sampling Sites of Range/Browse MDP Monitoring Sites

produced at each plot.

When grazing has occurred and part of the forage has been removed, the estimate will be adjusted by the degree of utilization.

$$\% \text{ Utilization} = \frac{\text{Average Productivity Per Ungrazed Plot} - \text{Average Productivity Per Grazed Plot}}{\text{Average Productivity Per Ungrazed Plot}} \times 100$$

The range productivity data are analyzed to compare pre-development conditions with those during development.

Damage from insects or frost is qualitatively assessed. Any damage is described and recorded and an estimate of damaged vegetation is made to determine the percent of the sampled vegetation which is affected.

3. Results

No results are available. The range transects will be established in April and sampled annually beginning September of 1978 (Table 3-1).

B. Browse

1. Objectives

Tract C-a development may reduce browse availability and therefore affect animal distribution in the vicinity of Tract C-a. The browse condition and utilization studies are designed to provide browse use information for areas adjacent to Tract C-a development.

2. Methods

Browse condition and utilization are measured along 30 transects (mixed brush -10, pinyon-juniper - 10, sagebrush - 10). The browse transects are located

in the same general vicinity as the range transects (Figure 3-3). Browse sampling is conducted annually in early May after deer have migrated through the Tract C-a area (Table 3-1).

Browse condition and utilization is estimated along transects consisting of 25 individual shrubs (Cole 1963). Browse species sampled include: juniper (Juniperus osteosperma), pinyon (Pinus edulis), antelope bitterbrush (Purshia tridentata), snowberry (Symphoricarpos oreophilus), big sagebrush (Artemisia tridentata), and true mountain mahogany (Cercocarpus montanus).

During field sampling, five parameters are examined and recorded.

Form classes:

1. All available, little or no hedging
2. All available, moderately hedged
3. All available, severely hedged
4. Partially available, little or no hedging
5. Partially available, moderately hedged
6. Partially available, severely hedged
7. Unavailable
8. Dead

Age Classes:

S - seedling - less than 0.3 cm basal diameter
Y - young - 0.3 to 0.6 cm basal diameter
M - mature - over 0.6 cm basal diameter
D - dacadent - more than 25 percent of crown surface is dead

Leader Use Estimates:

Percent of twigs or leaders which are available and show use

Hedging Classification:

Classification based upon the length and appearance (hedging) of the previous year's growth (the two-year old wood):

1. None to light
2. Moderate
3. Severe

Availability:

Visual estimate of the percent of the plant available to deer as browse, i.e., that portion less than six feet high.

The browse use data are used to compare differences in browse use for a specific plant species within a vegetation type before versus during MDP development and among individuals within each plant species during the MDP.

Damage from insects or frost is assessed qualitatively. Any damage is recorded and an estimate of damaged vegetation is calculated to determine the percent of the sampled vegetation which is affected.

3. Results

No results are available. The browse transects will be established and the individual shrubs measured in May of 1978 (Table 3-1) and measured annually thereafter.

3.3 FAUNA

A. Mule Deer

Mule deer are the most important game species in Colorado in terms of recreational use and money expended by hunters. The Piceance Creek basin mule deer herd is one of the largest migratory mule deer herds in North America.

Tract C-a is within the Colorado Division of Wildlife's (CDOW) Game Management Unit 22 (Piceance).

Moderate numbers of mule deer occur on Tract C-a during migration periods, particularly spring, and during mild winters. At other times mule deer are relatively uncommon on the tract. Consideration of the possible effects of Tract C-a oil shale development on mule deer is an integral part of RBOSC's Fish and Wildlife Management Plan.

During baseline studies several methods were used to assess the numbers and seasonal distribution of mule deer on Tract C-a. Methods used were pellet-group counts, aerial surveys,and track counts. All methods provided valuable information concerning mule deer on Tract C-a. A modification of the pellet-group count was chosen as the technique for studying mule deer populations on Tract C-a during the Interim Monitoring Period and for the MDP. This technique was chosen because it is being used (on an experimental basis) by CDOW in the Piceance Creek basin.

1. Objectives

The objectives of the RBOSC mule deer MDP monitoring program are: to obtain semi-annual indices to mule deer density in a 9 x 9 mile (81 sq mi) study area centered on Tract C-a (Figure 3-4); to compare these indices with those obtained by CDOW from Game Management Unit 22; and, if possible, to compare mule deer densities within various portions of the 81 sq mi study area.

2. Methods

Tract C-a is in the center of a 9 x 9 mile (81 sq mi) study area which is divided into blocks (approximately 3 x 3 miles or 9 sq mi each). Quarter sections (160 acres, 64 ha) are randomly selected from each block. The total number of quarter sections chosen depends on the results of initial sampling efforts.

During initial sampling, 20 plots or 2 transects of 10 plots each (ca. 100 sq

ft (1/1000 ha) each) are randomly spaced within 63 randomly selected quarter section sampling units (Figure 3-4). The boundary of each plot is determined by placing one end of a 5.8 foot (1.78 m) long chain on a center stake and walking around the stake with the opposite end of the chain pulled taut. Pellet-groups found within the circular plots are counted. To qualify as a group, six or more pellets must be present. Groups on the boundary of a plot are counted if one-half or more of the total number of pellets are within the plot. All pellet-groups are removed from the plots each time the plots are visited. Sampling plots are marked with a numbered metal stake at the center of each plot.

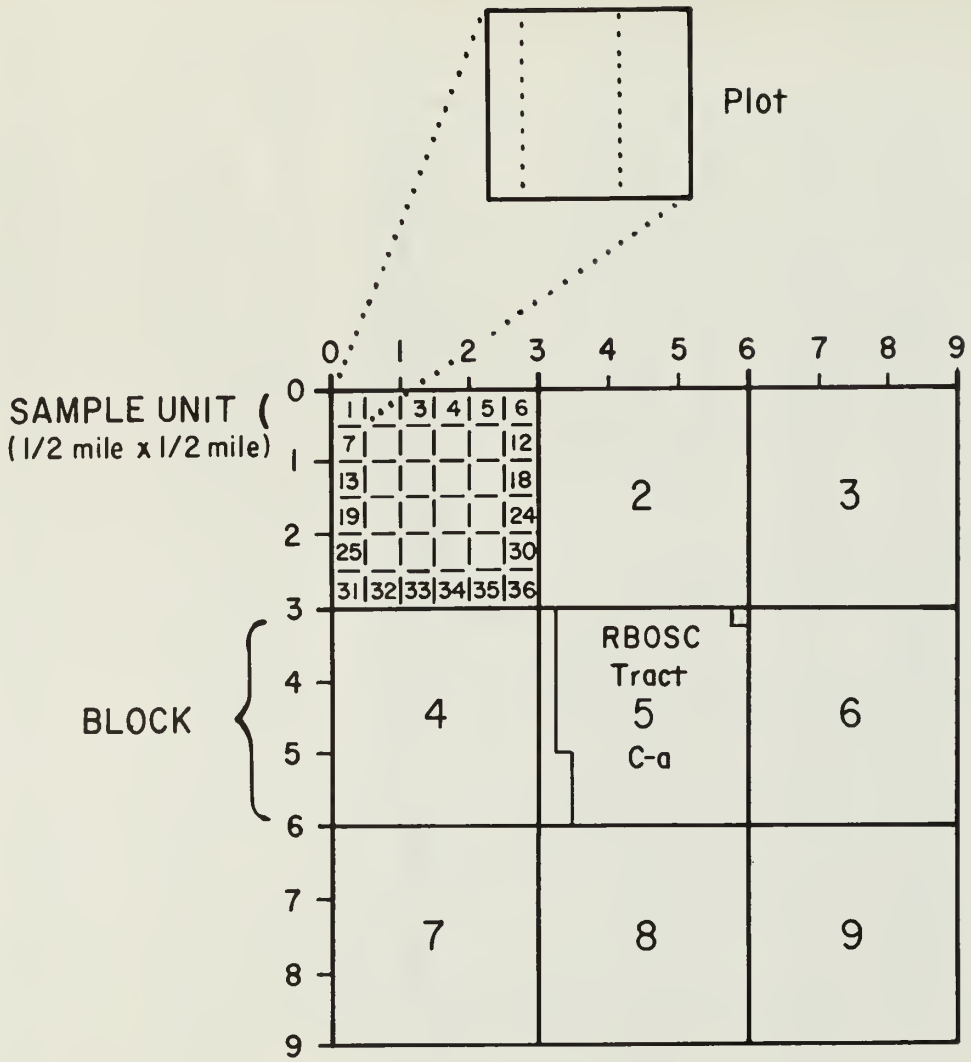
Pellet-group counts are made twice a year, once in the Spring (May) and once in the Fall (September), to determine the number of pellet groups deposited in the summer and during migration and wintering periods. Actual counting begins with the second sampling period (May 1978). Sampling will be conducted during each Spring and Fall for the subsequent five years (Table 3-1).

3. Results and Discussion

The mule deer pellet-group plots for the MDP were established September 9-26, 1977 in the Tract C-a study area (Figure 3-5). A total of 1260 plots was established. Additional pertinent information on the establishment and location of the mule deer pellet-group plots is presented in Table 3-2. From the counts of pellet-groups to be taken in May 1978, indices of mule deer densities in the Tract C-a study area will be computed for the winter period. Sample size required for subsequent pellet-group analyses will also be determined from the May 1978 data.

B. Feral Horse Abundance

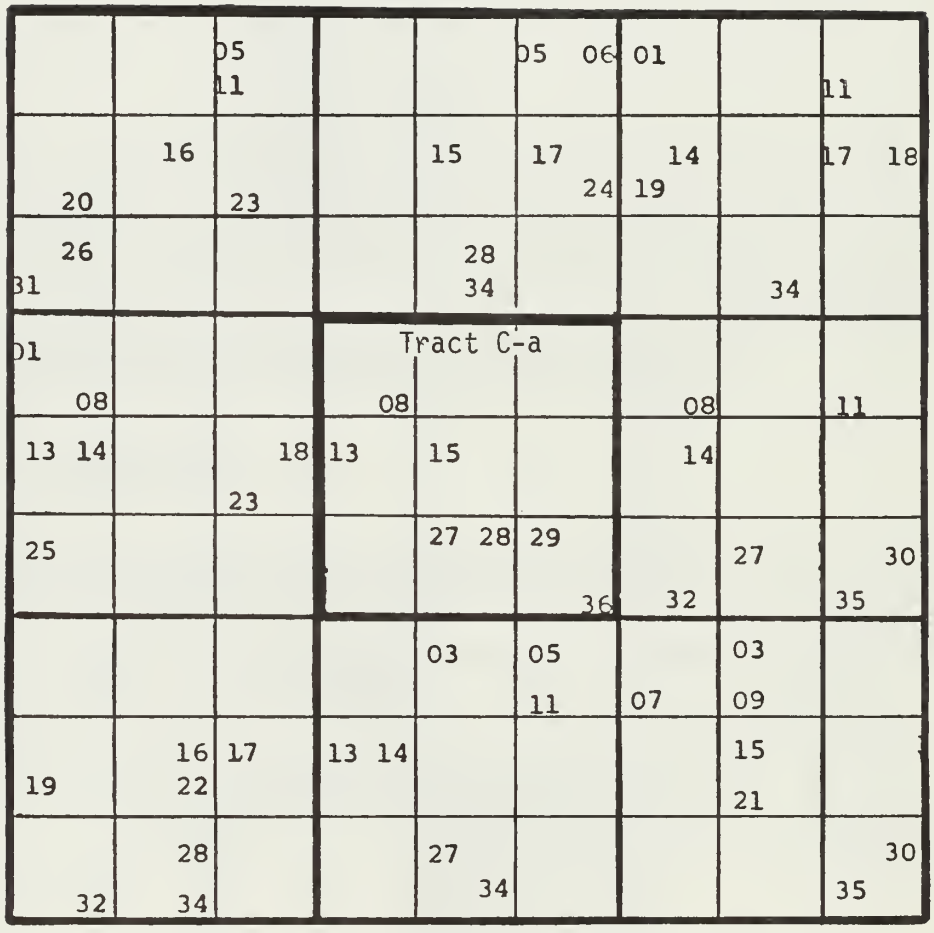
Feral horses occur on and in the vicinity of Tract C-a. These horses are protected under federal law and are under the jurisdiction of the BLM. Feral horses can compete with cattle and, to a lesser extent, with mule deer for available forage. During the baseline studies, the distribution and abundance of feral horses were studied by aerial surveys and opportunistic sightings.



plot = ca. 100 square ft. (1/1000 ha)
sample unit = 160 acres (ca. 64 ha)
block = 9 square miles

20 plots per sample unit
36 potential sample units per block
9 blocks in the RBOSC Study Area

Figure 3-4. Study Area for Mule Deer Pellet Group Counts, RBOSC Modular Development Phase Monitoring Program



*Number of sample units is indicate; See Table 3-2 for additional detail.

Figure 3-5. Sample Units* Selected for Mule Deer Pellet-Groups Study RBOSC Monitoring Program.

Table 3-2. Pertinent information on the establishment and location of mule deer pellet group plots on Tract C-a. (See Figure 3-5 for locations of sample units.)

Sample Unit	Transects	Date Established	Personnel	Location and Remarks
1-26	4-9	9/9	DER	1-3 on road N then E then S; return to 1-3 then S for 1-2 + 1-1
1-05	5-10	9/14	DER	labeled 2-5; NW benchmark at 0(1-04) S to 1-11-1-10 (Sec 1-11)
1-20	3-8	9/14	DER	2-10 S then N then N
1-31	5-10	9/16	DER	1-5 on road N to 1-10; 2-1 from 4-01-2-10 see below
1-11	2-7	9/14	DER	labeled 2-11; start at 1-05 from 1-1 90E to 2-1 then N to 1-05-2-10
1-16	1-6	9/16	WJC	from road on hilltop E to 1-1 N then E then S
1-23	3-8	9/16	WJC	1-3 S of road S then W then N by road then E then S to 1-4
2-15	2-7	9/20	DER	2-10 S of road on E edge of gully-S then W then N
2-05	2-7	9/14	WJC	2-7 or 8 N or road then W then S cross road then E then N to road
2-28	3-8	9/12	JWD	2-34-1-1 N thru 2-28-1-10 then E then S thru 2-34-2-1
2-17	4-9	9/14	WJC	1-8 on road by big tree 1 mi. NE of M4
2-34	3-8	9/12	JWD	See 2-28 above
2-06	2-7	9/14	WJC	1-10 N of road S then E then N
2-24	5-10	9/20	DER	1-10 S then E then N
3-19	3-8	9/16	WJC	from 3-14-1-1 W to 2-10 S then W then N-may not be in right place
3-17	5-10	9/14	JWD	5-1 N then 3-11-2-1 N then E 7-10 then S then W 3-17-2-10
3-18	1-6	9/14	JWD	1-1 N then E 6-10 then S
3-11	2-7	9/14	JWD	See above 3-17 + 3-18
3-34	3-8	9/12	DER	1-1 N then E then S - road thru unit
3-14	3-8	9/15	WJC	2-10.4 mi SW from road X then S then W then N
3-01	4-9	9/14	WJC	2-5 N of road .3 mi from turn N then W then S then E then N to 2-4
4-08	2-7	9/13	DER	2-1 then N then W then S - see TRR
4-14	4-9	9/13	DER	2-8 on raod N + returned then S then W then N
4-18	5-10	9/13	JWD	1-1 S of road N then E then S
4-13	3-8	9/13	DER	2-8 on road N + returned then s; 1-8 on road N + returend then S
4-25	5-10	9/13	DER	1-6 on road N- return - S return; 2-7 on road N + return then S
4-01	3-8	9/16	DER	from 1-31-1-1 W to 1-10 S then E then N then E to 1-31-2-1N
4-23	3-8	9/13	JWD	2-10 S then W then N
5-12	5-10	9/14	JWD	NOT USED - PART OF CONSTRUCTION - 5-15 SUBSTITUTED
5-10	-	-	-	NOT USED - PART OF CONSTRUCTION - 5-15 SUBSTITUTED

Table 3-2. (Continued)

Sample Unit	Transects	Date Established	Personnel	Location and Remarks
5-27	5-10	9/12	JWD	2-1 N from 528 thus W then S
5-29	5-10	9/12	DER	2-1 on road N then W then S
5-28	4-9	9/12	JWD	2-1 N then W then S on 1-10 then W to 5-27-2-1
5-08	4-9	9/13	JWD	2-1 from drill pad then N then W then s on 1-10
5-36	2-7	9/12	DER	1-10 then S then E then N
5-13	4-9	9/13	JWD	1-1 on road N then E then S
5-15	1-6	10/20	DER	2-3 W of drill pad M9 S then W then N then E then S to road
6-30	1-6	9/15	DER	1-1 N then E then S; will be hard to find-see DER
6-11	2-7	9/14	JWD	2-1 from road then N then W then S
6-35	4-9	9/16	JWD	road ends SE of 2-1; start 2-1 N then W then S
6-14	1-6	9/12	WJC	1-10 from 8-08-1-1 S then E then N then E to 8-08-2-1 N
6-08	3-8	9/12	WJC	start E of water gauge station 1-10 S then W to 6-14-1-10
6-27	3-8	9/16	DER	2-1 on road N then W then S
6-32	3-8	9/15	JWD	1-1 on road N then E then S
7-32	1-6	9/16	DER	1-8 or 9 on road N + return then S then E then N
7-16	4-9	9/21	DER	2-1 N then W then S
7-22	1-6	9/13	WJC	2-3? S or road S to 2-1 S to 7-28-2-1 S to 7-34-2-2 see 7-34
7-28	1-6	9/13	WJC	7-22, 7-28 + 7-34 in order-all short transects
7-34	2-7	9/13	WJC	E from 2-1 to 1-1 N to 7-28-1-1 N to 7-22-1-1 N then W see 7-28
7-19	1-6	9/16	DER	2-4 or 5 at road S back then N + back; 1-? is same from road
7-17	5-10	9/21	DER	1-1 N then E then S
8-14	1-6	9/13	WJC	road thru-open country
8-03	4-9	9/15	WJC	2-1 on road N then W then S
8-34	3-8	9/15	WJC	2-1 is 2 mi. SW from draw then N then W then S
8-13	5-10	9/13	WJC	road thru-open country
8-05	1-6	9/12	WJC	? 1-10 near road S to 8-11-1-10 S then E then N to 8-05-2-1 N
8-11	2-7	9/12	WJC	done with 8-05
8-27	2-7	9/21	DER	2-10 on road S then W then N
9-09	4-9	9/15	DER	1-1 on road N then E then S
9-03	1-6	9/15	JWD	See DER-road not no mpa? 1-1 then N then E then S
9-15	2-7	9/15	JWD	1-10 W of road X 2-10 on road - done W/9-21
9-35	5-10	9/15	JWD	2-1 on road N then W then S
9-30	1-6	9/15	DER	2-1 on road N then W then S
9-21	1-6	9/15	JWD	done W/ 9-15 Start at 9-15-2-10 & 1-10
9-07	5-10	9/15	DER	2-10 on road S then W then N

Similar methods will be used during the MDP.

1. Objectives

The objective of feral horse monitoring studies is to provide qualitative information concerning the status of feral horses in the RBOSC study area.

2. Methods

Feral horses on Tract C-a and within three miles of the tract boundary (i.e., same study area as mule deer) are counted annually in January. Transects are flown with a fixed winged aircraft and the location and number of horses observed are recorded. The aerial census data will be supplemented by general observations (number; activity when observed, e.g., watering, feeding) of horses recorded during other terrestrial ecology studies in May and September (Table 3-1).

3. Results and Discussion

Feral horses were observed frequently within the 81 sq mi study area during the September-November, 1977 period. These observations were opportunistic and were influenced by the activities connected with the establishment of mule deer study plots. Bands of feral horses were seen most frequently on Airplane Ridge, 84 Mesa, Dead Horse Ridge and in Corral Gulch. The aerial observations in January will be conducted with the aid of BLM personnel who are experienced in counting feral horses from the air; individual bands will be identified at that time. General behavioral characteristics of each band obtained during other times of the year for each band will supplement aerial survey data.

C. Threatened and Endangered Species

Baseline and interim monitoring studies indicate that Tract C-a does not provide critical habitat for any state or federally endangered species. Greater sandhill cranes were observed during the baseline studies on 84 Mesa, at the

Stake Springs impoundment, and east of 84 Ranch. A whooping crane was sighted east of 84 Ranch. Neither of these species was observed during the specific studies designed to detect their presence during the Interim Monitoring period. Because RBOSC MDP activities are not expected to affect the areas where sightings have been made, a separate program for endangered species has not been included in the MDP monitoring program.

Numerous biologists will be conducting studies on and near Tract C-a during all parts of the year. Observations of any threatened or endangered species will be reported to AOSO and appropriate studies, as determined by RBOSC and AOSO, will be initiated.

LITERATURE CITED

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SECTION 4

AQUATIC STUDIES

From October 1974 through September 1976, aquatic biological baseline data were collected from the surface waters of Tract C-a, from Yellow Creek (near its confluence with the White River, and from the White River. A total of 35 sampling sites was included in the Baseline Monitoring Program which was designed to characterize the aquatic biota and their habitats. Sampling intensity was greatest during the Spring, Summer, and Fall when biological activity was highest. During the baseline studies, the species composition, relative abundance and distribution of phytoplankton, zooplankton, aquatic macrophytes, periphyton, benthos, and fish were determined. In addition, studies of age, growth, condition, and reproduction of fishes of the White River and Yellow Creek were completed.

A limited variety of aquatic habitats occur on or near Tract C-a. These habitats include small, marshy ponds and small spring-brooks. Approximately 18 miles north of Tract C-a are Yellow Creek, a segment of a small perennial stream, and the White River, a relatively large, turbulent river.

The RBOSC aquatic baseline studies indicated that phytoplankton, zooplankton, and aquatic macrophytes play relatively unimportant roles in the aquatic ecosystems of the area. The baseline studies also revealed that periphyton are the major primary producers and that benthic macroinvertebrates are the primary aquatic consumers on the tract. Fish were found to occur only in Yellow Creek and the White River. The distribution of aquatic macrophytes was limited to a few pond habitats.

From September 1976 to August 1977, RBOSC also conducted an interim aquatic biological monitoring program. The completeness of the baseline aquatic data precluded the need to collect additional data on all baseline parameters during the interim monitoring period. There was, however, a need to monitor important elements of the aquatic ecosystem during this interim period to identify and characterize any major changes which might occur during that time. Thus, during the interim period, samples of periphyton and benthos were collected and physical measurements were taken during the late fall and in the spring at three of the sampling sites utilized during baseline studies (Station 13, 20, and 29) (Figure 4-1).

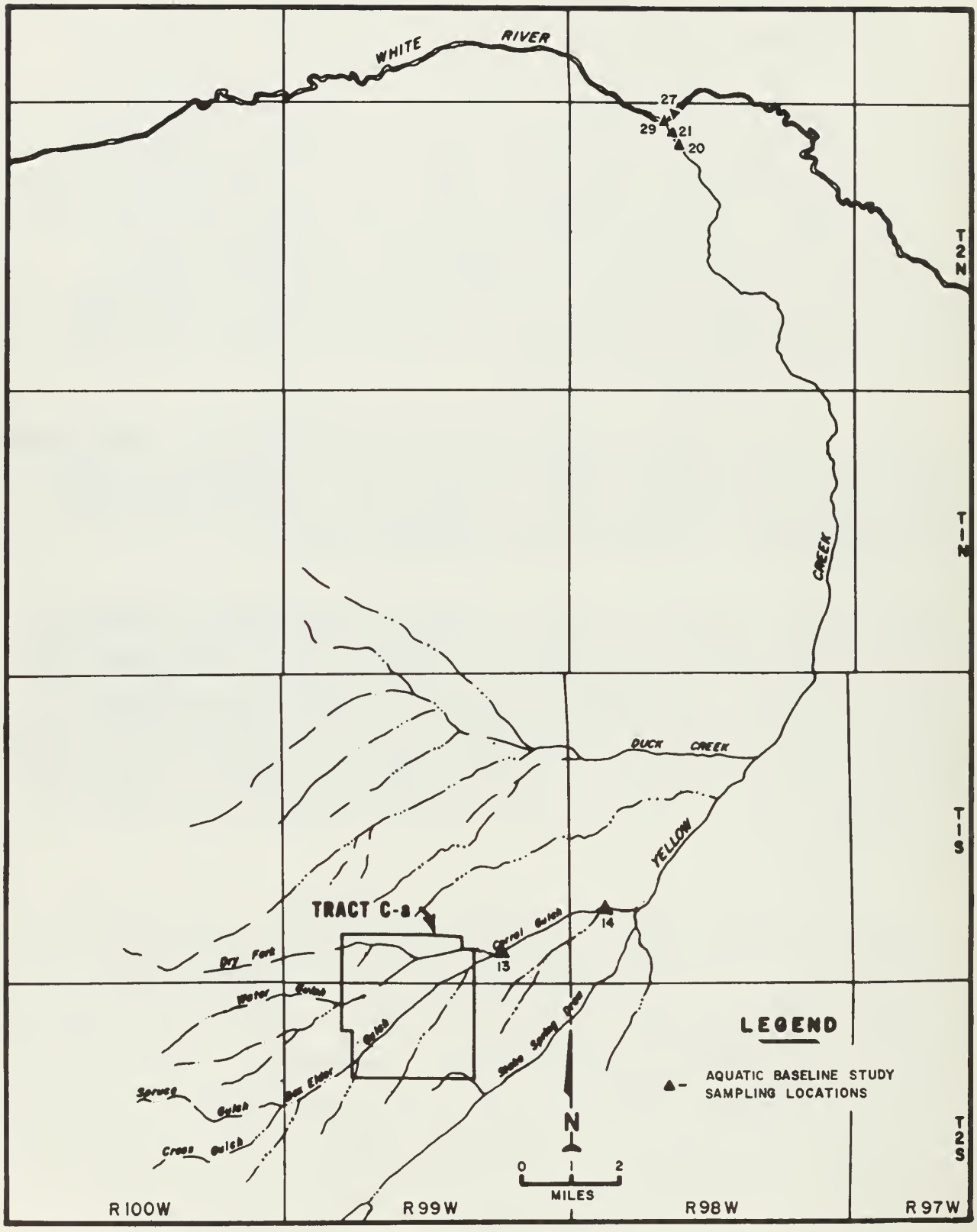

Figure 4-1. Aquatic Ecology Development Monitoring Sampling Sites

In October 1977, RBOSC initiated the MDP Aquatic Monitoring Program. This program was based upon a detailed analysis of the aquatic baseline data and upon projected potential impacts of modular development on Tract C-a.

A total of six sampling sites has been chosen for the MDP Aquatic Monitoring Program (Figure 4-1). The sampling sites include:

- Station 13 (spring-brook habitat) at the USGS gaging station in Corral Gulch (east)
- Station 14 (pond habitat) in Corral Gulch (east)
- Station 20 (spring-brook habitat) at the USGS gaging station on Yellow Creek
- Station 21 (spring-brook habitat) on Yellow Creek below the USGS gaging station
- Station 27 and 29 (White River back channel habitats) near the confluence of Yellow Creek with the White River.

Sampling, at least initially, is being conducted five times per year to allow comparison of monitoring and baseline data. Sampling is scheduled for April, June, July, August, and October during 1978 and during subsequent years of RBOSC modular development (Table 4-1). This report includes the results of the October 1977 aquatic biological sampling, the first under the new MDP Monitoring Program.

4.1 ABIOTIC PARAMETERS

A. Physical Measurements

1. Objectives

The objectives of taking physical measurements during the MDP Aquatic Monitoring studies are to monitor selected physical characteristics of the streams at each sampling site and to relate these characteristics to baseline chemical and biological conditions. The physical measurement program also includes those chemical parameters which are measured in conjunction with field sampling.

Table 4-1. Aquatic Studies Monitoring Schedule

Parameter	Location	Start Date	Frequency
	Abiotic Component		
Physical Measurements			
Stream Velocity Turbidity Dissolved Oxygen pH Specific Conductance Depth Width Stream Substrate	Stations 13, 14 20, 21, 27, 29 (See Figure 4-1)	Oct. 1977	5 times/year (Apr., June, July, Aug., Oct.)
Water Quality Measurements (White River)			
Boron Calcium Chloride Fluoride Magnesium Nitrate Orthophosphate Potassium Total Phosphate Silica Sulfate Sodium Alkalinity Total Dissolved Solids	Stations 27, 29 (See Figure 4-1)	Oct. 1977	5 times/year (Apr., June, July, Aug., Oct.)
	Biotic Component		
Periphyton	Stations 13, 14 10, 21, 27, 29 (See Figure 6)	Oct. 1977	5 times/year (Apr., June, July, Aug., Oct.)
Benthos	Stations 13, 14 20, 21, 27, 29 (See Figure 4-1)		5 times/year (Apr., June, July, Aug., Oct.)

The physical parameters selected for these monitoring studies are those which may be influenced by development (e.g., increases in siltation and turbidity and decreased flows) and which have been shown to be of particular significance to the important aquatic organisms observed during baseline studies.

2. Methods

The following methods are used to measure selected physical characteristics at each sampling site. These measurements are made concurrently with the collection of chemical and biological samples. Stream velocity is measured with a Gurley flowmeter or equivalent. The stream substrate is visually classified at each station at the same time as benthic samples are collected. The turbidity of each sample is determined with a Hach Photometric Turbidimeter or equivalent. Field measurements of dissolved oxygen are made according to the alsterbeg (Azide) modification of the Winkler Method using phenyl-arsene-oxide (PAO) as titrant (American Public Health Administration, APHA 1976).

Other parameters (and methods of measurement) which are determined in the field include pH (portable meter), specific conductance (portable meter), water temperature (thermistor or equivalent), depth, width, and total alkalinity (colorimetric; APHA 1976).

3. Results and Discussion

A comparison of the results of physical measurements taken during the October RBOSC aquatic baseline and the October 1977 MDP studies is presented in Table 4-2. Results of October 1977 measurements are shown in Table 4-3.

The physical conditions observed at Stations 13 and 14 near Tract C-a in October 1977 were very similar to those measured during RBOSC baseline studies in October 1974 and October 1975. In Yellow Creek and the White River, total alkalinities and specific conductance were somewhat higher in October 1977 than during the baseline October sampling periods. These higher values are likely related to the greater influence of groundwater on streamflows during the extended period of drought which occurred in northwestern Colorado in 1977.

Table 4-2. Comparison of Physical and Chemical Characteristics of Streams from RBOSC MDP Studies (1977) and RBOSC Baseline Studies (1974 - 1975).

Parameter	1974	1975	1977
	STATION 13		
Water Temperature (°C)	10	13	9
Conductivity (μmhos/cm)	1,200	1,200	1,200
Dissolved oxygen (mg/l)	8.9	8.4	8.0
Alkalinity, total (mg/l)	410	421	401
pH	7.8	7.8	7.8
Substrate[1]	Sa, Gr	Sa, Gr	Gr
Width	36"	24"	42"
Depth	1"; 1½"	3"	2"
Velocity (ft/sec)	0.5; 0.6	1.9	0.7
	STATION 14		
Water Temperature (°C)	8	14	8
Conductivity (μmhos/cm)	1,800	1,800	1,700
Dissolved oxygen (mg/l)	13.4	14.4	9.8
Alkalinity, total (mg/l)	454	520	521
pH	8.2	8.3	7.7
Substrate[1]	Cl	Si	Sa, De
Width	12"	36"	3
Depth	6"	6"	2"
Velocity (ft/sec)	1.3	0.4	0.7

Table 4-2. (Continued)

Parameter	1974	1975	1977
	STATION 20		
Water Temperature (°C)	7	11	11
Conductivity (µmhos/cm)	3,000	3,850	4,100
Dissolved oxygen (mg/l)	8.7	10.6	7.1
Alkalinity, total (mg/l)	1,149	1,485	1,658
pH	8.6	8.7	8.6
Substrate [1]	Gr	Gr, Sa	Gr, Sa
Width	28"	48"	22"
Depth	4½"	1"; 5"	7½"
Velocity (ft/sec)	1.7	1.3	1.9
	STATION 21		
Water Temperature (°C)	8	8	12
Conductivity (µmhos/cm)	3,000	3,880	4,100
Dissolved oxygen (mg/l)	9.9	10.7	7.9
Alkalinity, total (mg/l)	1,244	1,567	1,650
pH	8.6	8.7	8.8
Substrate [1]	Sa, Gr	Sa, Gr	Gr
Width	5' 10"	3'3"	3'
Depth	3"; 7"	3"	2"; 4.5"
Velocity (ft/sec)	0.2; 1.4	1.3	0.7; 1.3

Table 4-2. (Continued)

Parameter	1974	1975	1977
	STATION 27		
Water Temperature (°C)	11	9	9
Conductivity (µmhos/cm)	600; 600; 700	775; 700; 700	900; 900; 900
Dissolved oxygen (mg/l)	12.1	11.1	9.6
Alkalinity, total (mg/l)	199	186	214
pH	8.6	8.3	8.3
Substrate[1]	Co	Co, Gr	Co
Width	45'	50'	39'
Depth	2"; 19"	10"; 22"	1";10"
Velocity (ft/sec)	0.4; 0.6	0.2; 1.0	0.8; 1.1
	STATION 29		
Water Temperature (°C)	11	9	9
Conductivity (µmhos/cm)	855; 750; 690	875; 760; 710	900; 1050; 1200
Dissolved oxygen (mg/l)	10.8	10.9	9.7
Alkalinity, total (mg/l)	224	192	269
pH	8.7	8.3	8.1
Substrate[1]	Co	Co; Gr	Co
Width	22'7"	26'	26'
Depth	1"; 12"	8"; 13"	2"; 8"
Velocity (ft/sec)	2.3; 3.4	1.8; 4.5	1.2; 2.3

[1]Substrate abbreviations:
Gr = Gravel
Sa = Sand
De = Detritus
Co = Cobble
Cl = Clay
Si = Silt

Table 4-3. Physical and Chemical Characteristics of Streams, RBOSC Aquatic MDP Studies October, 1977

Parameter	Station 13	14	20	21	27	29
Water Temperature (^{o}C)	9	8	11	12	9	9
Conductivity (µmhos/cm)	1,200	1,700	4,100	4,100	900;900;900	900;1,050;1,200
Dissolved oxygen (mg/l)	8.0	9.8	7.1	7.9	9.6	9.7
Alkalinity, total (mg/l)	401	521	1,658	1,650	214	269
pH	7.8	7.7	8.6	8.8	8.3	8.1
Substrate[1]	Gr	Sa,De	Gr,Sa	Gr	Co	Co
Width	42"	3"	22"	36"	39'	26'
Depth	2"	2"	7.5"	2";4.5"	4";10"1"	4";8";2"
Velocity (ft/sec)	0.7	0.7	1.9	0.7;1.3	0.8;1.1	1.2;2.3
Turbidity (JTU)					59	67

[1]Substrate abbreviations:
Gr = Gravel
Sa = Sand
De = Detritus
Co = Cobble

Concentrations of DO were generally lower in all streams during October 1977; this is also likely due to the greater influence of groundwater on streamflows in the area.

B. Water Quality Measurements

1. Objectives

The objective of this aspect of the aquatic monitoring studies will be to monitor those chemical characteristics which baseline data analyses (RBOSP Final Environmental Baseline Report 1977) have shown to contribute most to the natural variability in White River water quality and thereby to assess natural variability in water quality. Water quality studies in other surface waters are included in hydrology studies (Section 5).

2. Methods

The following sampling sites (Figure 4-1) are included in the White River water quality monitoring program:

- Station 27 (above the confluence with Yellow Creek)
- Station 29 (below the confluence with Yellow Creek)

Table 4-4 lists the water quality parameters, analytical methods, and methods of sample preservation which are being used.

3. Results Discussion

Results of October 1977 water quality analysis of White River waters above and below the confluence with Yellow Creek are presented in Table 4-5.

Table 4-6 and 4-7 include a comparison of the results of the October 1977 water quality analyses of White River waters above and below the confluence with Yellow Creek, with those obtained during the baseline studies. It should be noted that the sampling locations utilized during the MDP monitoring are not identical to those used during baseline studies.

Table 4-4. RBOSC White River Water Quality Analyses

Parameter	Methodology	Sample Preservation
Alkalinity (total)	Colorimetric	Refrigeration
Boron	APHA[1] 405A	None Required
Calcium	Atomic Absorption	None Required*
Chloride	Potentiometric	None Required
Fluoride	Electrode	None Required
Magnesium	Atomic Absorption	HCl
Nitrate	APHA[1] 419C	$HgCl_2$
Orthophosphate	EPA[2]	$HgCl_2$
Potassium	Atomic Absorption	HCl
Total Phosphate	EPA[2]	$HgCl_2$
Silica	APHA[1]	HCl
Sulfate	APHA[1] 427C	Refrigeration
Sodium	Atomic Absorption	None Required
Total Dissolved Solids	Filtration & Evaporation	None Required

[1]American Public Health Association (APHA) 1976

[2]Environmental Protection Agency (EPA) 1975

*HCl is an optional preservative

Note: Samples will be retained for three months following submission of the year-end report.

Table 4-5. Water Quality Data for the White River, RBOSC MDP Aquatic Monitoring Studies, October 1977. (Data are expressed in mg/l, unless otherwise noted.)

Parameter	Replicate A	Replicate B
STATION 27		
Boron (B), diss	<0.5	<0.5
Calcium (Ca), diss	84	83
Chloride (Cl), diss	43	43
Fluoride (F), diss	0.17	0.17
Magnesium (Mg), diss	28	31
Nitrate (N), diss	<0.2	<0.2
Phosphorus, Ortho (P), diss	0.01	<0.01
Phosphorus, Total (P), diss	0.02	0.01
Potassium (K), diss	2.8	2.7
Silica (Si), diss	8.3	8.3
Sodium (Na), diss	67	66
Solids, diss	512	529
Sulfate (S), diss	60	60
Turbidity (JTU)	58	60
STATION 29		
Boron (B), diss	<0.5	<0.5
Calcium (Ca), diss	74	79
Chloride (Cl), diss	46	46
Fluoride (F), diss	0.21	0.19
Magnesium (Mg), diss	31	31
Nitrate (N), diss	<0.2	<0.2
Phosphorus, Ortho (P), diss	<0.01	<0.01
Phosphorus, Total (P), diss	<0.01	0.02
Potassium (K), diss	2.9	3.0
Silica (Si), diss	8.1	8.4
Sodium (Na), diss	110	100
Solids, diss	625	622
Sulfate (S), diss	63	64
Turbidity (JTU)	65	68

diss = dissolved

Table 4-6. Comparison of Water Quality Data from the White River (upstream of Yellow Creek) from RBOSC Aquatic Baseline (1975) and MDP (1977) Studies. (Results are expressed as the means of two replicates and are mg/l unless otherwise noted.)

Parameter	1975	1977
	Station 25	Station 27
Boron (B), diss	<0.5	<0.5
Calcium (Ca), diss	69	84
Chloride (Cl), diss	31	43
Fluoride (F), diss	0.22	0.17
Magnesium (Mg), diss	22	30
Nitrate (N), diss	<0.2	<0.2
Phosphorus, Ortho (P), diss	<0.01	<0.01
Phosphorus, Total (P), diss	0.03	<0.02
Potassium (K), diss	2.4	2.8
Silica (Si), diss	6.5	8.3
Sodium (Na) diss	49	67
Solids, diss	441	521
Sulfate (S)	143	60
Turbidity (JTU)	7	59

diss = dissolved

Table 4-7. Comparison of Water Quality Data from the White River (downstream of Yellow Creek)from RBOSC Aquatic Baseline (1975) and MDP (1977) Studies. (Results are expressed as the means of two replicates and are mg/l unless otherwise noted.)

Parameter	1975	1977
	Station 34	Station 29
Boron (B), diss	<0.5	<0.5
Calcium (Ca), diss	67	77
Chloride (Cl), diss	29	46
Fluoride (F), diss	0.19	0.20
Magnesium (Mg), diss	21	31
Nitrate (N), diss	<0.2	<0.2
Phosphorus, Ortho (P), diss	<0.01	<0.01
Phosphorus, Total (P), diss	0.03	<0.02
Potassium (K), diss	2.2	3.0
Silica (Si), diss	6.9	8.3
Sodium (Na), diss	49	105
Solids, diss	428	624
Sulfate (S), diss	138	64
Turbidity (JTU)	7	67

diss = dissolved

Above the confluence of Yellow Creek, the concentrations of calcium, chloride, magnesium, silica, sodium, and dissolved solids were higher in the White River in October 1977 than those recorded in October 1975. Turbidity was also higher in October 1977 than in 1975. The dissolved sulfate concentration was lower in October 1977 than in 1975.

Below the confluence of Yellow Creek, the concentrations of calcium, chloride, magnesium, silica, sodium, and dissolved solids were also higher in the White River in October 1977 than those reported in 1975. Turbidity was also higher in October 1977 than in 1975. The dissolved sulfate concentration was lower in October 1977 than in 1975.

From the data presented above, it is apparent that the concentrations of the same constituents were higher both above and below the confluence with Yellow Creek in October 1977 than in October 1975. These higher concentrations are probably related to the increased importance of groundwater flow to the total stream flow due to drought conditions.

4.2 BIOTIC PARAMETERS

A. Periphyton

1. Objectives

The objectives of periphyton studies are to monitor species composition, relative abundance, biomass, and diversity of periphyton and to assess the effects of site development on communities of these organisms.

2. Methods

Calulations of the sample size requiring accuracy of 26 to 80 percent of the mean (total relative abundance) for each type of habitat were used in establishing the periphyton sampling program. At Stations 13 (spring-brook habitat), 14 (pond), and 27 and 29 (White River), six replicate samples are collected. Four of these are used to determine abundance and the remaining two are used to determine

biomass. At Stations 20 and 21 (Yellow Creek), 10 replicate samples are collected. Eight of these are used to determine relative abundance and the remaining two are used to determine biomass.

Samples of periphyton are collected from areas of equivalent flow, if possible. Rocks that have relatively flat upper surfaces and are positioned at mid-depth in riffles are selected for the collection of samples. The rocks are carefully removed from the streams and each replicate is taken by removing the periphyton from a 50 cm^2 area with a toothbrush and water (Northern States Power Co. 1974). The resultant suspension of material is preserved in five percent neutralized formalin.

In the laboratory, the preserved periphyton samples are diluted to a constant volume, an aliquot is removed, centrifuged, and washed with distilled water. The samples are then stained and dehydrated in the centrifuge, using successive spinnings and decantings. A number of drops of the final xylene-periphyton suspension is placed on a microscope slide with Hyrax, heated gently, and covered with an ultra-thin coverglass. The final mounts are retained in the permanent voucher collection. See the Aquatic Annual Report (RBOSP 1976) for more detailed methods.

Periphyton are studied using a microscope and counting all organisms appearing in one randomly chosen transect at 1000X (oil immersion). The whole slide is then surveyed at 100X to identify and enumerate any larger rare species. Counts are expressed as cells per unit area; these data are used to compute relative abundance and species diversity.

Biomass determinations are made by drying the samples at a constant temperature of 105 C, weighing, ashing at 550 C, and reweighing (Vollenweider 1969). The calculated ash-free dry weights are estimates of the organic weight of the periphyton.

3. Results and Discussion

Total mean cell densities of the most abundant algal taxa found in October periphyton samples collected during RBOSC Aquatic Baseline (1974, 1975) and

MDP (1977) studies are presented in Table 4-8. Mean dry and organic weights of these periphyton samples are presented in Table 4-9. Species lists are presented in the appendix.

Mean total algal cell densities in periphyton collections at Station 13 in October 1974, 1975, and 1977 suggested no apparent trend. Highest total algal cell densities were observed in 1975, and lowest densities were observed in 1977. Highest mean organic weight occurred in the 1974 samples, whereas the lowest organic weight was found in 1975.

Achnanthes minutissima and Navicula cryptocephala were the dominant taxa at Station 13 in October of each year. Other taxa which were common or abundant each year were Achnanthes lanceolata, Navicula arvensis, Nitzschia acicularis, and Nitzschia palea. Lyngbya spp, Plectonema spp, Bicoeca lacustris, Navicula pelliculosa, and Surirella ovata were abundant in one or two of the October collections.

Mean total cell densities and organic weights were low at Station 14 in October 1974 and 1975, whereas in 1977, both values were the highest observed for the October collections. Taxa abundance differed in October for each sample year, although Achnanthes minutissima and Navicula cryptocephala were present each year and were abundant in samples collected in October 1977. In 1977, Navicula pelliculosa and Nitzschia acicularis were the most abundant species, but they occurred in low numbers or were absent in 1974 and 1975 samples. The flood at Station 14 in 1974 which modified it from a pond-type habitat to a stream-type habitat during 1975, and its later reversion back into a pond in 1977, was probably a major cause of the observed changes in species composition.

The periphyton communities were similar at Stations 20 and 21. Total mean cell densities at Stations 20 and 21 were lower in October 1977 than in October 1974. Organic weights were lowest at both stations in 1975. Achnanthes minutissima was abundant in 1974 and 1975, but was scarce at both stations in 1977 (Table 4-8). Achnanthes minutissima is reported to respond to high dissolved oxygen concentrations (Lowe 1974). The low densities which were observed in 1977 may have resulted from the slightly lower DO concentrations in 1977 over previous October samplings.

Table 4-8. Comparison of Mean Densities of the Most Abundant Algal Species Observed in the Periphyton During Sampling, RBOSC MDP Studies (October 1977) and RBOSP Aquatic Baseline Studies (October 1974 and 1975). (Densities are expressed as in cells/mm^2 except data for filamentous taxa which are expressed as the number of 50µm units.)

Taxa	1974	1975	1977
	STATION 13		
CYANOPHYTA			
Calothrix spp			
Lyngbya spp	956	124	
Plectonema spp	518		
CHRYSOPHYTA			
Achnanthes lanceolata	653	1,689	334
A. minutissima	5,378	11,312	2,199
Bicoeca lacustris		3,289	758
Cymbella affinis	67	290	
Gomphonema intricatum	428	1,632	1,046
G. Olivaceum	146		
Meridion circulare	281	238	257
Navicula arvensis	281	769	796
N. cryptocephala	7,223	2,949	1,726
N. pelliculosa		388	960
Nitzschia acicularis	79	2,110	385
N. capitellata		84	
N. denticula		51	
N. frustulum	158	68	209
N. holsetica		11	123
N. linearis	214	25	237
N. palea	281	606	563
Surirella ovata	45	90	1,076

Table 4-8 . (Continued)

Taxa	1974	1975	1977
	STATION 14		
CHLOROPHYTA			
Ulothrix spp	14		
CHRYSOPHYTA			
Achnanthes minutissima	641	491	73
A. lanceolata	2	3	2
Cyclotella meneghiniana		10	16
Cymbella affinis		54	
C. microcephala		22	
Navicula cryptocephala	9	20	1,486
N. pelliculosa			6,112
Nitzschia acicularis		1	3,134
N. capitellata			384
N. frustulum	34		475
N. latens			165
N. linearis	2		26
N. palea	9	1	624
Synedra amphicephala	11		
S. minuscula		6	
S. ulna	22		95
	STATION 20		
CYANOPHYTA			
Calothrix spp	2,059		98
Lyngbya spp	68		
CHRYSOPHYTA			
Achnanthes minutissima	7,718	7,629	24
Cyclotella meneghiniana	855	60	26
Cymbella affinis	7,830		
C. perpusilla	23	330	11
Fragilaria vaucheriae	90		
Gomphonema affine	45	38	36
Navicula cryptocephala	214	131	6
N. pelliculosa		23	
Nitzschia frustulum	124	356	80
N. latens		27	13
N. palea	45	203	29
Surirella ovata			6
Synedra amphicephala	11	15	2
S. minuscula		38	
S. pulchella	23	68	119
S. ulna	214		1

Table 4-8 . (Continued)

Taxa	1974	1975	1977
	STATION 21		
CYANOPHYTA			
Calothrix spp	540		416
Lyngbya spp		63	
CHRYSOPHYTA			
Achnanthes minutissima	5,996	6,464	14
Cyclotella meneghiniana	236	9	10
Cymbella affinis	9,034		
C. perpusilla	113	81	5
Gomphonema intricatum	11	71	28
Navicula cryptocephala	45	29	6
N. viridula		8	11
Nitzschia frustulum	68	48	199
N. palea	101	45	185
Synedra amphicephala	34		
S. pulchella			42
S. ulna	79		1
Surirella ovata		5	14
	STATION 27		
CYANOPHYTA			
Calothrix spp	1,103	124	476
Lyngbya spp	596	1,317	
CHRYSOPHYTA			
Achnanthes minutissima	34	169	154
Amphora ovalis var. pediculus	23	495	72
Cocconeis pediculus	168	23	619
Diatoma vulgare	79	79	94
Epithemia sorex	5,411	7,594	380
Gomphonema intricatum	22	113	162
G. olivaceum	259	79	187
Navicula cryptocephala	259	1,969	762
N. salinarum var. intermedia	315	776	242
N. tripunctata	113	787	209
Nitzschia chasei		405	179
N. dissipata	146	2,025	542
N. frustulum	90	450	397
Surivella ovata		810	

Table 4-8 . (Continued)

Taxa	1974	1975	1977
	STATION 29		
CYANOPHYTA			
Calothrix spp			272
Lyngbya spp	1,170	1,962	
Oscillatoria spp	799	96	
CHRYSOPHYTA			
Achnanthes minutissima	956	197	91
Amphora ovalis var. *pediculus*	11	2,043	41
Cocconeis pediculus	90		41
Cymbella affinis	371	57	41
C. sinuata		338	
Diatoma vulgare	68	51	8
Epithemia sorex	2,486	13,231	190
Gomphonemia intricatum		6	702
G. olivaceum	158	113	140
Navicula cryptocephala	889	807	759
N. salinarum var. *intermedia*	338	452	107
N. tripunctata	102	198	265
N. viridula	11	45	223
Nitzschia chasei			198
N. dissipata	371	1,146	3,358
N. frustulum	382	587	1,634
N. palea	113	28	58

Table 4-9. Comparisons of Dry and Organic Weights of Periphyton During RBOSC MDP Studies (October 1977) and RBOSC Aquatic Baseline Studies (October 1974 - 1975).

Station	1974		1975		1977	
	Dry Weight	Organic Weight	Dry Weight	Organic Weight	Dry Weight	Organic Weight
13	0.8825	0.1477	0.5973	0.1177	0.8331	0.1214
14	0.2539	0.0235	0.1118	0.0231	7.6423	0.3974
20	3.4235	0.1683	0.3545	0.0463	0.9848	0.1972
21	3.6123	0.1814	0.4738	0.0540	0.8660	0.1572
27	17.2300	0.7691	5.6426	0.4730	30.4826	1.2094
29	5.7952	0.4751	2.9386	0.3747	12.9528	0.6559

Cymbella affinis was abundant at Stations 20 and 21 only in 1974 (Table 4-8). Periphyton cell densities were very low in 1977; Calothrix spp, Nitzschia spp, and Synedra pulchella were the most abundant taxa.

Total mean cell densities at Stations 27 and 29 were highest in 1975 and lowest in 1977 (Table 4-8), whereas highest mean organic weights at these stations were observed in 1977 (Table 4-9). The most abundant species at Stations 27 and 29 in October 1974 and 1975 was Epithemia sorex. Calothrix spp, Lyngbya spp, Navicula cryptocephala, Nitzschia dissipate, and Nitzschia frustulum were common or abundant in all October collections from Stations 27 and 29. Two species were abundant only once; Cocconeis pediculus in 1977 and Amphora ovalis var. pediculus in 1975.

There tended to be similar species assemblages at each respective station in October of each collection year, with the exception of Station 14. No trends were apparent in periphyton densities.

Organic weights of periphyton samples and total mean cell densities did not appear to be related. This may have been related to the numbers of invertebrates present in the periphyton collections.

B. Benthos

1. Objectives

The objectives of the benthos (macroinvertebrate) studies are to assess the effects of site development on benthos communities. Benthos studies are included in the RBOSC MDP monitoring program because benthic macroinvertebrates constitute the major component of the secondary trophic level in aquatic ecosystems on and near Tract C-a, and because of their limited mobility and consequent susceptibility to physical and chemical changes.

2. Methods

At each sampling site, three replicate samples are collected with a modified Hess sampler. During RBOSC aquatic baseline studies, this sampler was proven to yield quantitative results when used in rubble and gravel substrates.

The modified Hess sampler has been previously described in RBOSC work scopes as a modified Surber sampler. In reality, the modified Hess sampler used throughout the two years of Aquatic Baseline Studies, during Interim Monitoring Studies, and during the proposed Modular Development Phase Monitoring Stuides, is a modification of the original Surber square-foot sampler similar to that described by Waters and Knapp (1961). The modified Hess sampler (FD8-522 cm^2) is a lightweight, shallow-water benthos sampler. It is cylindrical or elliptical in shape and consists of a metal frame with #30 mesh (0.6 mm aperature) side curtains. The side screening prevents the inadvertant capture of drifting organisms.

After collection, benthos samples are washed in buckets that have bottoms fitted with a U.S. Standard No. 30 sieve, and are preserved with neutralized 10 percent formalin.

Standardized methods of sample processing and analysis are utilized in the laboratory. The benthic samples are first rinsed in 20 cm, No. 60 sieves with low pressure fine spray to remove specimens from rocks and any fine sediments. The samples are then hand-sorted under dissecting microscopes at 6X magnification. Organisms are removed from the sample and placed in petri dishes or watch-glasses containing water. Samples are systematically searched for individual organisms. Unidentified material is also removed along with the organisms and examined under dissecting microscopes. The organisms are stored in plastic capsules in 70 percent ethanol.

With few exceptions, benthic organisms are identifiable to genus without the use of special preparation. Organisms are identified to the lowest taxon possible. Individuals are usually identified under the dissecting microscope or, if necessary, with temporary slides (under water) under a compund microscope.

Chironomidae and Oligochaeta are cleared in xylene and then mounted on permanent slides in Canada balsam. Only complete oligochaetes with intact anterior portions are counted.

Only those individuals which are living at the time of collection, as indicated by presence of fleshy tissue, are counted for the purpose of estimating densities. Empty mollusc shells, exuvia, reproductive structures, etc. are retained; both to aid in identification and to compile qualitative species lists, but are not used for estimates of population densities. A special reference or voucher collection is maintained apart from other specimens.

3. Results and Discussion

A comprehensive species list for the October 1977 collection is provided in the appendix. As in the baseline years (October sampling), diversity of the benthic community was greatest in the White River due to heterogeneity of substrates which provide numerous microhabitats for colonization. Table 4-10 provides the mean densities of organisms for the most abundant benthic macroinvertebrate taxa from the 1974, 1975, and the 1977 MDP October samples based on the three replicates.

Total numbers of macroinvertebrates and numbers of species were lower during the MDP October sampling period. Drought conditions of 1977 could be a partial explanation for the lower numbers.

At Station 13, Chironomidae was the most abundant family of organisms. Diamesa was the most abundant genus of this family collected during October 1977. Drought conditions in 1977 may have caused the winter stoneflies that were common during 1974 and 1975 to either retreat further in the hyporheic zone or be killed during their resting stages. Because of extremely rapid recolonization capabilities of Baetidae, the population of these should fully recover from the effects of drought conditions within a short span of time. Because the habitat at Station 14 has changed to such a great extent over three years, very little can be concluded about the diversity or densities of the organisms present. In October of 1974 and 1975, Station 14 was a stable pond filled with aquatic

Table 4-10. Comparison of Most Abundant Benthic Macroinvertebrate Taxa Observed During RBOSC Aquatic MDP Studies (October 1977) and RBOSC Aquatic Baseline Studies (October 1975 and 1976) (Densities are expressed as organisms/m^2).

Taxa	1974	1975	1977
	STATION 13		
Nematoda	382	13	6
Oligochaeta	9,344	109	96
Baetidae	5,352	6	
Baetis sp	6	60	
Plecoptera	733	1,478	
Ceratopogonidae	44	6	6
Chironomidae larvae	39,079	374	2,057
Chironomidae pupae		48	78
Simuliidae	6,135		
Simulium sp	200		
Empididae		48	
Limnophora aequifrons	552	78	84
Limnophora discreta	119		
	STATION 14		
Oligochaeta	187	1,135	5,708
Hyalella azteca		29	
Baetidae		429	
Callibaetis sp	2,486	118	
Plecoptera		30	
Corixidae	89	15	
Deronectes sp		44	
Ceratopogonidae	44	118	24
Chironomidae larvae	3,918	1,032	459
Chironomidae pupae		59	205
Simuliidae	104	44	
Limnophora aequifrons	163		139
	STATION 20		
Nematoda		833	
Oligochaeta	94	6,238	24
Acari	32		
Collembola	25		
Baetidae		1,152	
Coenagrionidae	25	36	6
Ceratopogonidae	75	1,478	284
Chironomidae	1,228	398	193
Simuliidae	44	133	2,431
Limnophora aequifrons	19		

Table 4-10. (Continued)

Taxa	1974	1975	1977
	STATION 21		
Nematoda	6	6	
Oligochaeta	175	48	314
Acari	6	48	
Hayalella azteca	19		
Baetidae	19	60	
Callibaetis sp		6	6
Coenagrionidae		36	
Hydropsyche sp	6		6
Ceratopogonidae	94	36	446
Chironomidae larvae	2,162	446	169
Chironomidae pupae		42	
Simuliidae	320	790	495
Simulium sp		42	24
Limnophora aequifrons	13	6	
	STATION 27		
Oligochaeta	332	708	2,990
Baetidae	38	384	52
Baetis sp	25	33	7
Heptagenia sp	13	117	13
Rhithrogena sp	13	72	7
Ephemerella sp	132	540	33
Tricorythodes sp	169	143	787
Plecoptera	38	143	7
Hydropsychidae	44	98	39
Cheumatopsyche sp		33	26
Hydropsyche sp	19	325	7
Hydroptilidae	94	52	13
Limnophila sp		46	7
Chironomidae larvae	865	617	962
Chironomidae pupae		78	59

Table 4-10. (Continued)

Taxa	1974	1975	1977
	STATION 29		
Nematoda	119		7
Oligochaeta	520	1,566	1,489
Baetidae	345	884	247
Baetis sp	144	488	33
Rhithrogena sp	639	1,547	
Ephemerella sp	25	1,645	7
Tricorythodes sp	6	78	85
Plecoptera	151	865	
Hydropsychidae	1,090	566	59
Cheumatopsyche sp		364	
Hydropsyche sp	871	3,335	104
Ceratopogonidae	13	33	423
Chironomidae	320	1,566	351
Simuliidae	156	65	72
Empididae	25		189

macrophytes. In the spring of 1976, this pond was washed out. In October 1977, this area again is starting to show the presence of pond organisms, but at this time the pond community has not reestablished itself (e.g., Callibaetis, Hyalella azteca, and Corixidae have not returned). The Oligochaeta, in particular Limnodrilus udekimanus, were the most abundant group of organisms at Station 14 during October 1977. The Chironomidae, the next most abundant group of organisms, was dominated by the genus Diamesa.

Macroinvertebrate densities and species numbers at Yellow Creek (Stations 20 and 21) also declined during October 1977 as compared to baseline conditions of 1974 and 1975. There are numerous possibilities as to why this may have occurred: low flows, an increase in water temperature, an increase in dissolved solids, and potential for decreased dissolved oxygen.

Blackflies (Simuliidae) were the most abundant forms at Stations 20 and 21 during October 1977. There was a noticeable decrease in the Chironomidae from 1974 to 1977. The Oligochaeta were more abundant in 1977 at Station 21 than during October 1974 or 1975. At Station 20, however, Oligochaeta were much more numberous during October 1975.

Macroinvertebrate composition in the White River (Station 27 and 29) remained fairly constant in all three years of October sampling. Although decreases occurred for certain taxa during October 1977 as compared to baseline years, there were noticeable increases in other taxa. At Station 29, Rhithrogena, a rheophilic species, was not present during October 1977. Also, there was a decrease in the mayflies, Baetis, and Ephemerella at Station 29 and an increase in Tricorythodes. These changes in composition strongly suggest a change in current velocity at Station 29 with more deposition of detritus and fine sediments in this general area than in the baseline years. Conditions provided by the drought of 1976 and 1977 could have been responsible for such changes.

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SECTION 5

HYDROLOGY STUDIES

Extensive hydrology data were collected from Tract C-a during the baseline, October 1974 to September 1976, and interim September 1976 to September 1977, Tract C-a monitoring programs. The hydrology program included studies of precipitation, surface water, and groundwater. The United States Geological Survey (USGS) operated seven gaging stations in the vicinity of Tract C-a during this period. These stations continuously and automatically monitored stream temperature, conductivity, flow and sediment load during the spring, summer and fall. During the winter, three stations were operated. The USGS also conducted extensive monthly water sampling and analysis programs at each of these stations during periods of stream flow. A more limited analysis program was conducted during the interim period.

Six springs and seeps were studied in detail during the baseline period. Velocity and water quality data gathered at these springs and seeps indicated they have their source in alluvial or shallow bedrock aquifers.

Seven alluvial aquifer monitoring holes were completed in the vicinity of Tract C-a. Three failed to produce water during drilling and did not contain water during the baseline program. Four holes had continuously measurable water levels at the onset of drilling to the end of the baseline period. Water level, pH, temperature, and conductivity were measured in the field monthly for each of these eight holes. Extensive water quality analyses were also performed on water samples taken from these holes on a monthly basis. In order to provide continuity through the interim period, a single alluvial monitor hole was selected and monitored on a quarterly basis. This hole was G-S S-11.

During various pre-lease programs, two deep groundwater aquifers were identified and some of their characteristics identified. RBOSC gathered additional data during these drilling, monitoring, and pumping test programs. The results of all of these programs have shown the upper aquifer to be in and near the Mahogany Zone of the Green River Formation. Water quality of the upper aquifer was generally found to be better than that of the lower aquifers. Water level was continuously monitored in several wells in each aquifer. The data from G-S 4-5 in both the upper and lower aquifers were

continuously recorded through the interim period to provide continuity with the baseline data.

Data have been presented in Quarterly Reports 1 through 11, DDP of 1976, The Final Environmental Baseline Report, and two Interim Studies Semi-Annual Reports dated March and October 1977.

5.1 SURFACE WATER

A. Streams

1. Objectives

The objectives of the surface water monitoring are to determine if surface water quantity and quality are affected by the Tract C-a MIS mining, and construction of associated facilities.

2. Methods

Surface water quantity and quality are monitored through the use of six surface water gaging stations (Figure 5-1), by the USGS.

A. (09306237) Dry Fork near west line Tract C-a
B. (09306235) Corral Gulch near west line Tract C-a
C. (09306240) Box Elder Gulch near west line Tract C-a
D. (09306242) Corral Gulch east of Tract C-a
E. (09306255) Yellow Creek near White River, Colorado
F. (09306241) "Rinky Dink" Gulch near east line Tract C-a

Conductivity, temperature, and flow are monitored on a continuous basis. Quarterly monitoring includes the major ions (Ca, Mg, SO_4, Cl, K, HCO_3, CO_3) and sodium, fluoride, silica, pH, and alkalinity.

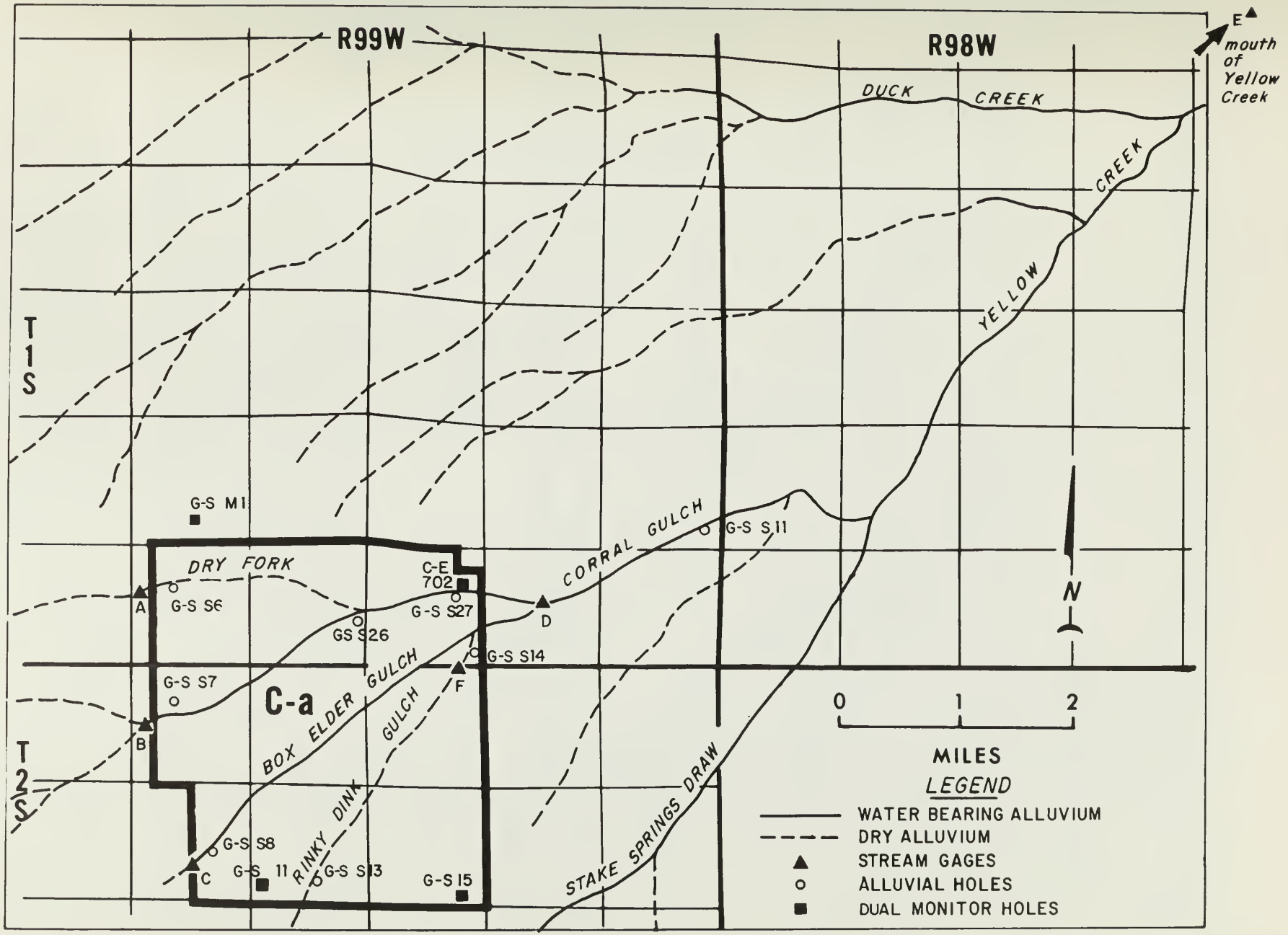

Figure 5-1. Locations of Monitoring Stations for Hydrology Studies During the MDP.

Semi-annual analyses are performed for the baseline constituents (Table 5-1) at all six surface water gaging stations and surface water impoundments where water is present.

3. Results and Discussions

Much of the data collected by the USGS during the MDP has not yet been analyzed and forwarded to RBOSC. The only data available from the USGS is the limited water quality data from station 09306242, Corral Gulch east of Tract C-a (Table 5-2). Most values reported for the MDP fall within maximum and minimum baseline ranges. Two exceptions are dissolved RA^{226}, which is 0.11 pci/l above the maximum baseline value, and dissolved natural uranium, which is 3.6 µg/l below the baseline minimum.

B. Springs and Seeps

1. Objectives

The objective of monitoring and observing major springs and seeps during the MDP is to determine if flow and conductivity are affected by dewatering and reinjection.

2. Methods

Specific conductance is measured by the use of a conductivity meter. Flowing water is measured by using a weir or a flume. One of these devices is maintained at six major springs and seeps located on and around Tract C-a (Figure 5-2). These measurements are made quarterly. The rationale for measuring flows from springs and seeps is based upon analysis of two-years of baseline data, which indicated that four of the springs and seeps studied in detail are hydrologically connected to the upper oil shale aquifer.

Perturbations to the water quality of springs and seeps will be detected by analysis of the conductivity data. The rationale for using conductivity as a detector parameter is based on a high correlation with changes in other

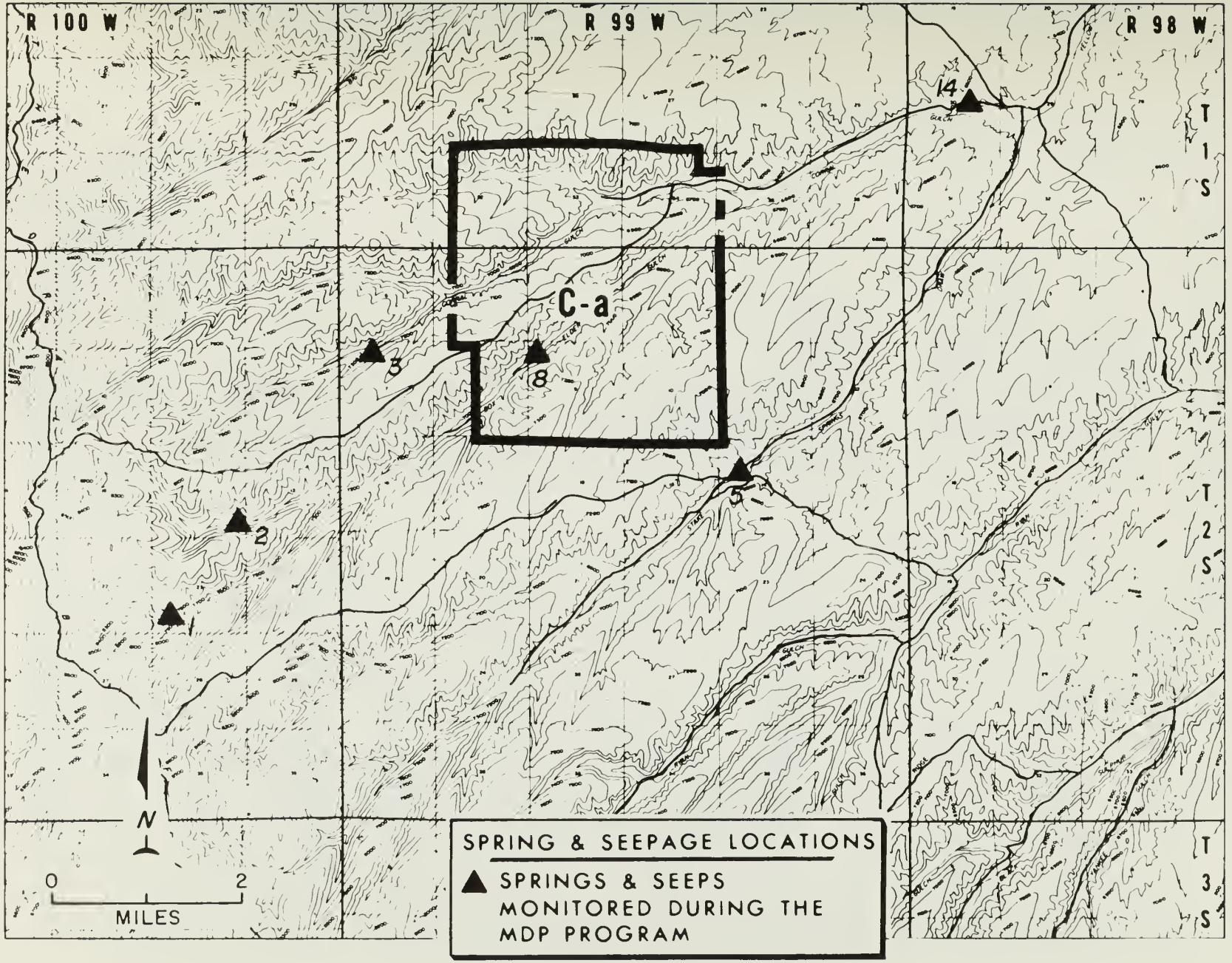

Figure 5-2. Springs and Seeps to be Monitored During the MDP

Table 5-1. Water Chemistry Parameters Analyzed Semi-Annually at the Surface Water Gaging Stations and Impoundments During RBOSC MDP Activities

Standard Wet Chemical Analysis[1]

Bromide
Alkalinity
Biological Oxygen Demand
Dissolved Organic Carbon
Boron
Selenium
Calcium
Conductance
Fluoride
Magnesium

Potassium
Silica
Sodium
Chemical Oxygen Demand
Fecal Coliform
Pesticides
Nitrogen, Ammonia
Total Coliform
Strontium
Cyanide

MBAS
Oil & Grease
Sulfate
Ammonia
Bicarbonate
Carbonate
Chloride
Color
Sodium Adsorption Ratio
Dissolved Solids

Kjeldahl Nitrogen
Nitrate Plus Nitrite
Odor
Dissolved Phosphate
Turbidity
Dissolved Oxygen
Phenols
Sulfide
pH
Temperature

Radioactivity

Gross Alpha
if 4 pci/l
then Ra^{226}
Natural Uranium

Gross Beta
if 100 pci/l
Then Sr^{90}
Ce^{137}

Total Phosphate
Ortho Phosphate
Suspended Organic Carbon
Aluminum
Arsenic
Cadmium
Chromium
Selenium
Mercury
Zinc
Iron
Lead

Spectrographic Analysis

Molybdenum
Lithium
Mangenese
Barium
Beryllium
Germanium
Gallium
Nickel
Titanium
Vanadium
Zirconium
Copper

[1]To EPA or detectable limits already established

Table 5-2. Results of Water Analysis Located at USGS Stream Gaging Station (09306242), Corral Gulch East of Tract C-a.

Parameter	Oct. 19 1977	Baseline Data			
		High	Low	Geo.Mean	No. of Analyses
Temperature (^{o}C)	12.0	22.00	3.00	11.47	65
Discharge (cfs)	0.28	0.74	0	--	--
Dissolved Oxygen (mg/l)	10.4	13.00	4.80	8.32	58
Specific Conductance (µmhos)	1150	1725.00	797.00	1231.54	59
pH	7.6	8.90	7.10	7.88	58
Atmospheric Odor	1	3.00	0	0	57
Radioactivity					
Gross Alpha					
Dissolved at U-Nat(µg/l)	18				
Suspended as U-Nat (µg/l)	< 0.4				
Gross Beta					
Dissolved as CS-137 (pci/l)	< 6.4	9.40	2.40	3.83	7
Dissolved as SR90/Y90 (pci/l)	< 5.1	7.50	2.00	3.10	7
Suspended as CS-137 (pci/l)	0.6				
Suspended as SR90/Y90 (pci/l)	0.5				
Dissolved RA-226 (pci/l)	0.21	0.10	0.05	0.07	4
Dissolved Natural Uranium (µg/l)	3.1	<13.00	<6.70	9.70	7

water quality parameters as determined during the statistical analysis of data collected during baseline monitoring. At each of the six springs and seeps to be studied during the MDP, conductivity measurements were made six times a year during baseline. Therefore, a comparison can be made between future conductivity readings and baseline data to verify that they are not greater than 20 percent more than the maximum nor less than 20 percent below the minimum rating during either the snowmelt runoff season or the base flow season. These seasons, as determined from baseline data, appear to run from February 1 until July 1, and from July 1 until January 31 for the snowmelt runoff and base flow seasons, respectively.

3. Results and Discussions

MDP monitoring results for springs and seeps is presented on Table 5-3. Maximum and minimum baseline data and data from the fall season of 1974 are also presented for comparison purposes.

Water temperature measured at the springs and seeps were within the range of those measured at the same locations during the baseline and fall of 1974.

The specific conductance of the water at those same springs monitored was within the minimum-maximum ranges measured during the baseline with one exception which marginally exceeded the maximum limit. In a comparison to the 1974 - 1977 fall readings the measured conductivity was very similar in all cases.

Flow was measured during the MDP using a flume or weir. In 1974, flow was measured as velocity with a current meter. Using the width and depth measurements along with the velocity measurements, a volumetric flow was computed for comparison purposes. Present flows at Spring 1 (near Cathedral Bluffs) and Spring 14 (near 84 Ranch) are similar to flows measured three years earlier.

Table 5-3. Temperature, Flow and Conductivity Data for Springs and Seeps in the Vicinity of Tract C-a

Spring	Temperature (°C)				Specific Conductance (μmhos/cm)				Flow (cfs)	
	Baseline		Oct-Nov	Oct	Baseline		Oct-Nov	Oct	Oct-Nov[1]	Oct[2]
	Min.	Max.	1974	1977	Min.	Max.	1974	1977	1974	1977
1. Cathedral Bluffs	1	19	1	6	825	950	875	920	0.048	0.046
2. Spruce Gulch	7	11	7	8	1000	1200	1000	1000	0.770	0.028
3. Maverick Spring	5	21	5	1	850	1300	1190	1025	0.006	0.047
5. Stake Springs Draw	3	22	5	12	1300	1500	1400	1400	0.505	0.095
8. Box Elder Gulch	5	12	9	10.5	850	1100	1100	1140	0.180	0.046
14. 84 Ranch	0	19	8	3.5	1550	2000	1800	1750	0.041	0.042

[1] Flow measured with current meter (computed figure using width, depth, and velocity measurements).

[2] Flow measured with Parshall flume of V-notch weir.

A larger volume of water flow was measured at Springs 2 (Spruce Gulch), 5 (Stake Springs Draw) and 8 (Box Elder Gulch) in 1974 than in 1977, however, more flow was measured at Spring 3 (Maverick Spring) on the latter date.

At no time was any spring measured to flow near or in excess of 1 cfs. Although temperature did vary for the same season of the year three years apart, conductivity varied little, and at only one location (Box Elder Gulch) did it exceed the baseline maximum slightly.

By the criteria set forth in the methods section for spring and seep pertubation detection, no change of the water quality at the springs or seeps has taken place.

5.2 GROUND WATER

A. Alluvial Aquifers

1. Objectives

The objectives of monitoring the alluvial aquifers are to determine if conditions have changed since the baseline data were collected and to detect impacts caused by accidental oil spills or releases of dewatering water into the alluvial aquifers.

2. Methods

During the baseline period, seven shallow alluvial monitor holes were drilled and monitored for the alluvial baseline program. Another eight holes were drilled as a part of the 84 Mesa program. Six original holes plus two new alluvial holes are being monitored to meet the objectives of the MDP monitoring program (Figure 5-1). G-S S-12 was dropped because it is located outside the area that will be affected during the MDP.

Water level is measured continuously at G-S S-7 and two new holes G-S S-26 and G-S S-27 by water level recorders. In addition, samples are collected

and analyzed quarterly for alkalinity, pH, sodium, silica, fluoride, conductivity, temperature, and the other major ions (Ca, Mg, SO_4, Cl, K, HCO_3). The alluvial holes are sampled and analyzed for all baseline constituents (Table 5-4) twice per year.

Should oil and grease be found to increase in its content over a period of time, then analyses will be made to determine the possible source. These analyses can determine the type of material, i.e, No. 2 diesel, unleaded gasoline, raw shale oil, etc., found in the water.

3. Results and Discussion

Continuous water level recorders were installed in alluvial hole G-S S-7, G-S S-26, and G-S S-27 on November 27 and 28, 1977. Water levels measured since the start of the MDP are shown on Table 5-5 and Figures 5-3 through 5-10, along with water levels from several preceding months for comparison purposes. G-S S-6, G-S S-13, and G-S S-14 were dry at the time of measurement as they were during the baseline and interim monitoring.

As can be seen on the above referenced figures, water levels in the alluvial holes are lower than at the same time last year, and reflect the continued general downward trend prevalent over the entire year. This trend can be accounted for by lack of recharge due to minimal snowmelt runoff in spring 1977.

Physical and chemical field measurements of temperature and specific conductance were within or very close to the same measurements made during baseline (Table 5-5).

Water quality data from the alluvial aquifers are presented in Table 5-6, along with corresponding baseline data for comparison purposes. Concentrations of most parameters fall within baseline limits, and many are close to the geometric mean of the baseline data. Two exceptions are pH, which is slightly more alkaline than the baseline maximum, and silica, which is slightly lower than baseline minimum.

Table 5-4. Parameters Measured or Analyzed at Selected Alluvial Wells During the RBOSC MDP Activities

Standard Wet Chemical Analysis[1]

Water level
Selenium
Aluminum
Ammonia
Arsenic
Bicarbonate
Bromide
Boron
Dissolved Organic Carbon
Calcium

Carbonate
Cadmium
Chloride
Alkalinity
Silica
Dissolved Solids
Fluoride
Iron
Lead
Chromium
Oil and Grease
Magnesium

Mercury
Nitrate plus Nitrite
Phenols
Cyanide
Chemical Oxygen Demand
Sodium
Strontium
Sulfate
Sulfide
Dissolved Phosphate

Potassium
Zinc
Color
Odor
pH
Temperature
Conductance

Radioactivity

Gross Alpha
if >4 pci/l
Then Ra^{226}
Natural Uranium

Gross Beta
If >100 pci/l
Then Sr^{90}
Ce^{137}

Spectrographic Analysis

Barium
Beryllium
Bismuth
Germanium
Gallium
Lithium
Copper
Manganese
Molybdenum
Nickel
Titanium
Vanadium
Zirconium

[1] To EPA or detectable limits already established

Table 5-5. Alluvial Aquifer Physical and Chemical Field Measurements for MDP and Baseline, RBOSC.

Obser. Hole No.	Date of Sample	Depth to Water Below Ground Surface (Feet)	Temperature °C			Specific Conductance (μmhos/cm)			pH
			Fall 77	Baseline Maximum	Baseline Minimum	Fall 77	Baseline Maximum	Baseline Minimum	
G-S S-6		Dry							
G-S S-7	10/10/77	27.29	6.2	11.28	6.11	1,220	1,440	990	8.0
	11/28/77[1]	27.91							
S-S S-8	10/10/77	41.14	8.0	14.00	7.89	990	1,150	860	8.1
G-S S-11	10/10/77	47.00	5.8	13.50	8.83	1,900	2,220	1,560	8.0
G-S S-13		Dry							
G-S S-14		Dry							
G-S S-26	10/28/77	27.9	10.5			1,275			8.3
	11/28/77[1]	28.07							
G-S S-27	10/27/77	25.2	10			1,500			8.0
	11/28/77[1]	26.11							

[1]Water levels only measured during the month

TABLE 5-6. Water Quality of Alluvial Aquifer Holes, October 1977, for MOP and Baseline, RBOSC

Parameter	MOP Hole No.					Baseline			
	G-S S-7	G-S S-8	G-S S-11	G-S S-26	G-S S-27	High	Low	Geo. Mean	Geo. Dev.
P. Alkalinity ($CaCO_3$)(mg/l)	<0.1	<0.1	<0.1	<0.1	<0.1				
MO Alkalinity ($CaCO_3$)(mg/l)	400	385	535	420	485	880	310	383	1.17
Ammonia (mg/l)	0.35		0.15		0.56	6.4	<0.1	0.36	2.49
Aluminum (mg/l)	0.2	1.0	1.0	0.2	0.1	1.2	<0.1	0.142	0.00214
Arsenic (mg/l)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.01	<0.011	0.002
Beryllium (mg/l)	<0.1	<0.1	<0.1	<0.01	<0.01	0.6	<0.02	0.106	0.005
Bicarbonate (mg/l)	490	420	655	505	590	680	360	458.7	1.19
Boron (mg/l)	<0.1	<0.1	<0.1	<0.1	<0.1	27	<0.01	0.19	0.007
Cadmium (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	1.1	<0.010	0.017	0.002
Calcium (mg/l)	105	74	90	120	130	210	39	96.4	1.38
Carbonate (mg/l)	<0.1	<0.1	<0.1	6	<0.1	48	<0.1	0.26	8.23
Chloride (mg/l)	9.9	9.9	23	13	20	41	1.3	12.8	1.73
Chromium (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	0.20	<0.010	0.011	0.0015
C.O.O. (mg/l)	74		25		35	85	5	16.4	2.18
Color (PCU)	14	50	21	18	33	--	--	--	--
Cyanide (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	0.01	1.0
Fluoride (mg/l)	0.2	0.2	0.1	0.7	0.6	0.7	0.1	0.26	1.73
Iron (mg/l)	<0.05	<0.05	<0.05	<0.05	<0.05	28	<0.05	1.029	0.0109
Lead (mg/l)	0.02	0.03	0.02	0.07	0.05	1.0	0.010	0.138	0.0035
Magnesium (mg/l)	19	28	92	60	48	145	3.7	57.04	1.78
Mercury (mg/l)	<0.001	<0.001	<0.001	<0.011	<0.001	<0.010	<0.001	0.0026	0.0029
Nitrate (mg/l)	2.2	3.4	6.4	4.1	1.9	165	0.1	3.9	2.21
Nitrite (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	--	--	--	--
Odor	Good	Good	Good	Good	Good	--	--	--	--
Oil & Grease (mg/l)	<1.0	<1.0	<1.0	<1.0	<1.0	--	--	--	--
pH	8.0	8.1	8.0		8.1	7.2	6.0	6.32	0.34
Phenols (mg/l)	0.004		0.014		<0.001	0.013	<0.001	0.0021	0.011
Phosphate (mg/l)	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	0.1	1.0
Potassium (mg/l)	1.3	3.0	2.3	2.7	4.5	14	<1.0	3.66	1.99
Radioactivity (pci/l)									
Gross Alpha	2.5	2.0	0.0		14	31	0.2	7.34	2.47
Gross Beta	0	0	0		0	35	1.0	9.5	2.54
Selenium (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.01	<0.0104	0.00136
Silica (SiO_2)	11	9.9	11	9.5	8.1	41.0	16.0	29.2	1.18
Sodium (mg/l)	185	150	260	130	250	350	66	151.1	1.57
Strontium (mg/l)	<0.1	<0.1	<0.1	1.2	1.2	5	1.4	2.5	0.00156
Sulfate (mg/l)	290	250	555	355	520	720	150	297	1.84
Sulfide (mg/l)	<0.1	<0.1	<0.1	<0.1	<0.1	1.60	<0.1	0.16	2.56
TDS (mg/l)	745	625	1250	840	1130	1650	640	777	1.15
TOC (mg/l)	6	14	5			292	2.0	18.7	344
Zinc (mg/l)	0.1	<0.1	0.1	0.1	0.1	3.2	0.010	0.292	0.00346

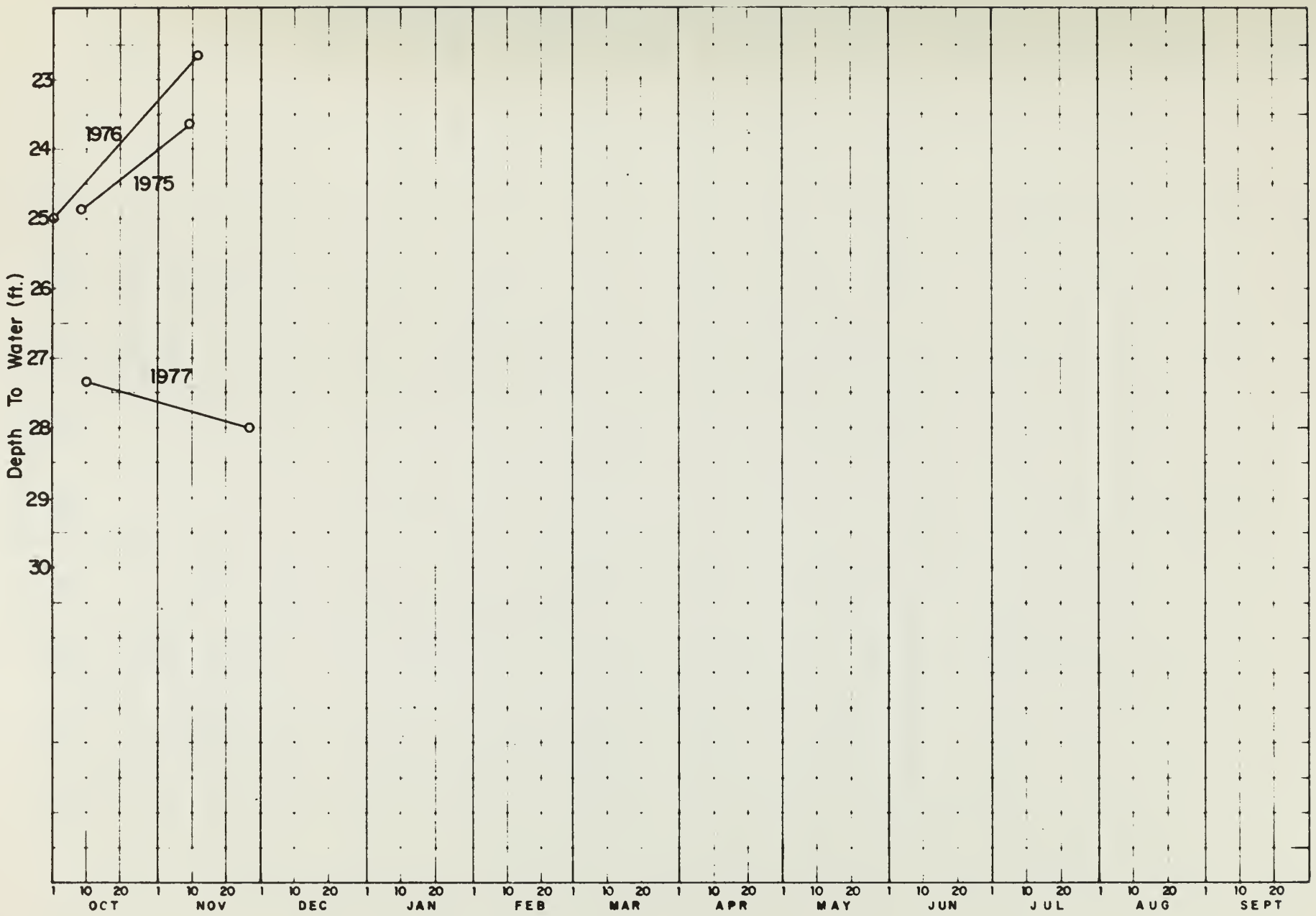

Figure 5-3. Depth to Water, Fall 1975, 1976, 1977, Alluvial Hole G-S S-7.

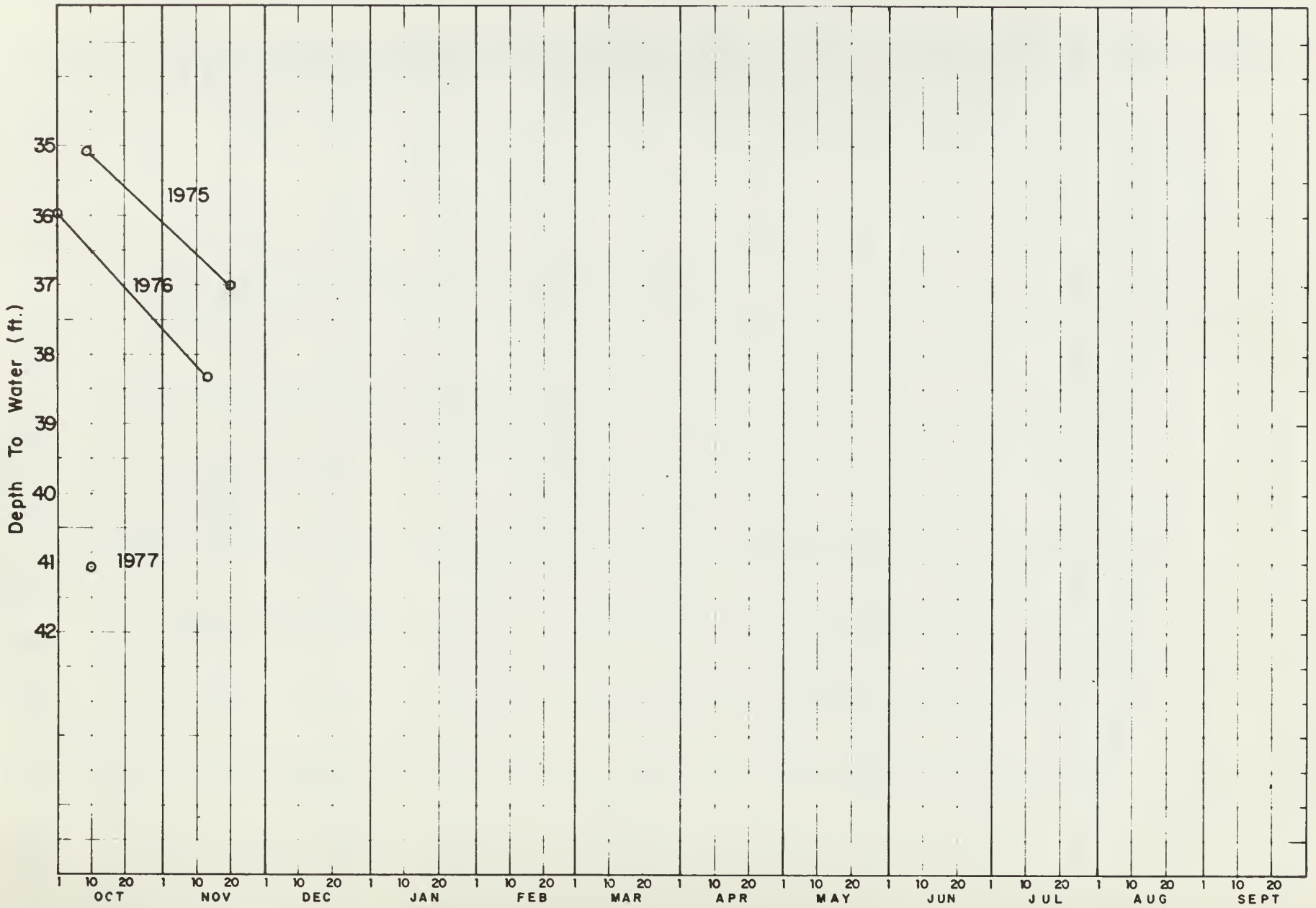

Figure 5-4. Depth to Water, Fall 1975, 1976, 1977, Alluvial Hole G-S S-8.

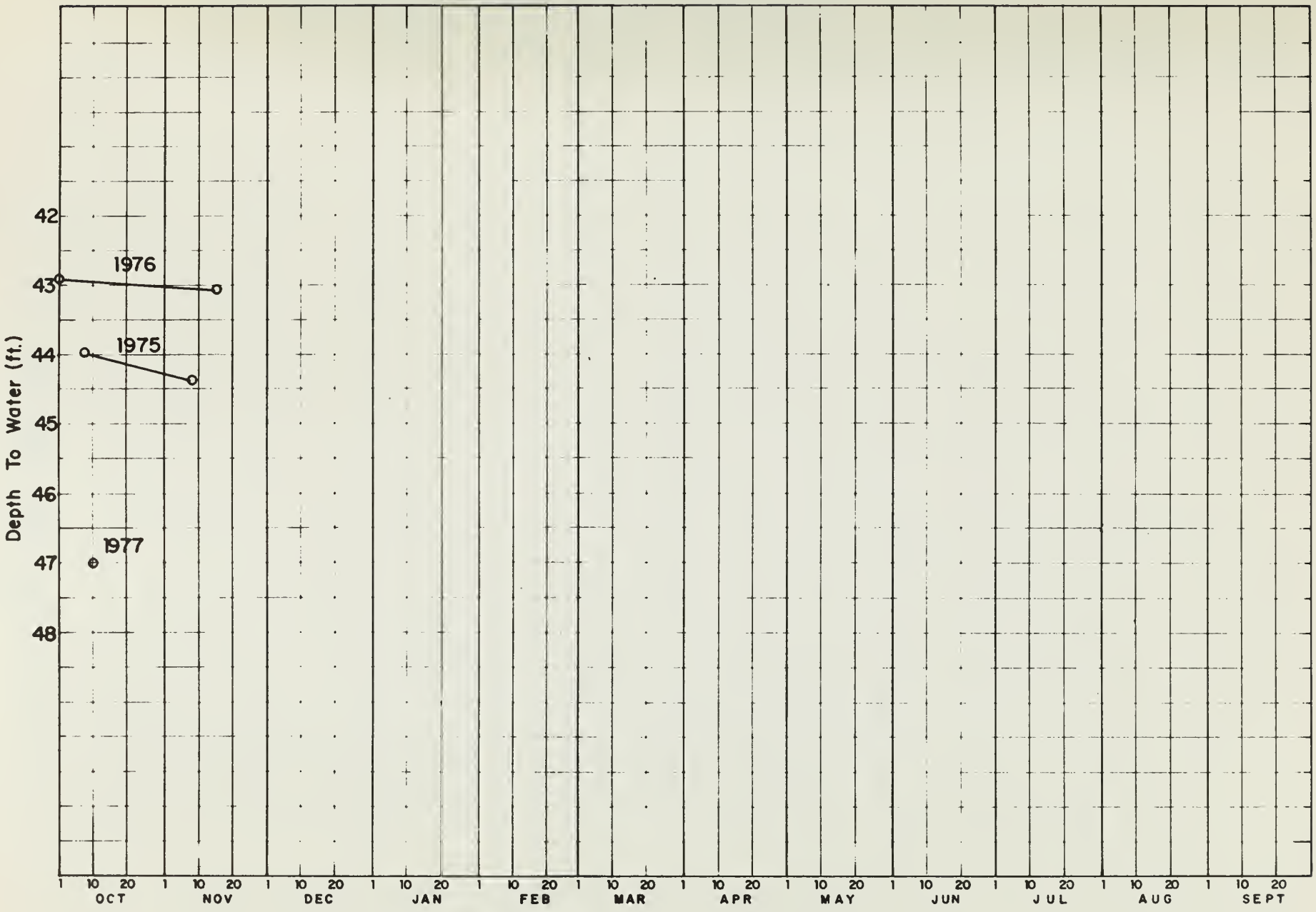

Figure 5-5. Depth to Water, Fall 1975, 1976, 1977, Alluvial Hole G-S S-11.

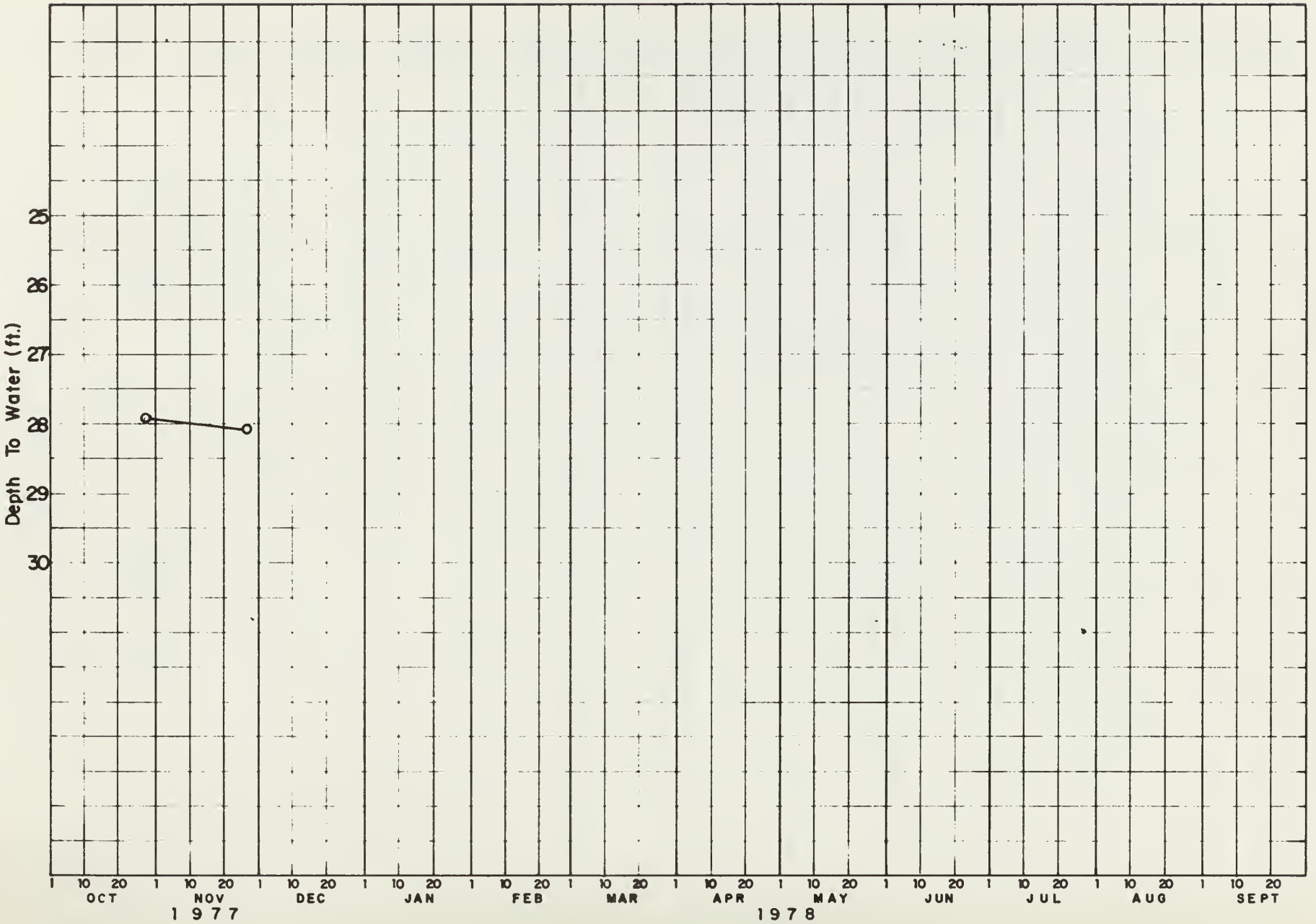

Figure 5-6. Depth to Water, Water Year 1978, Alluvial Hole G-S S-26.

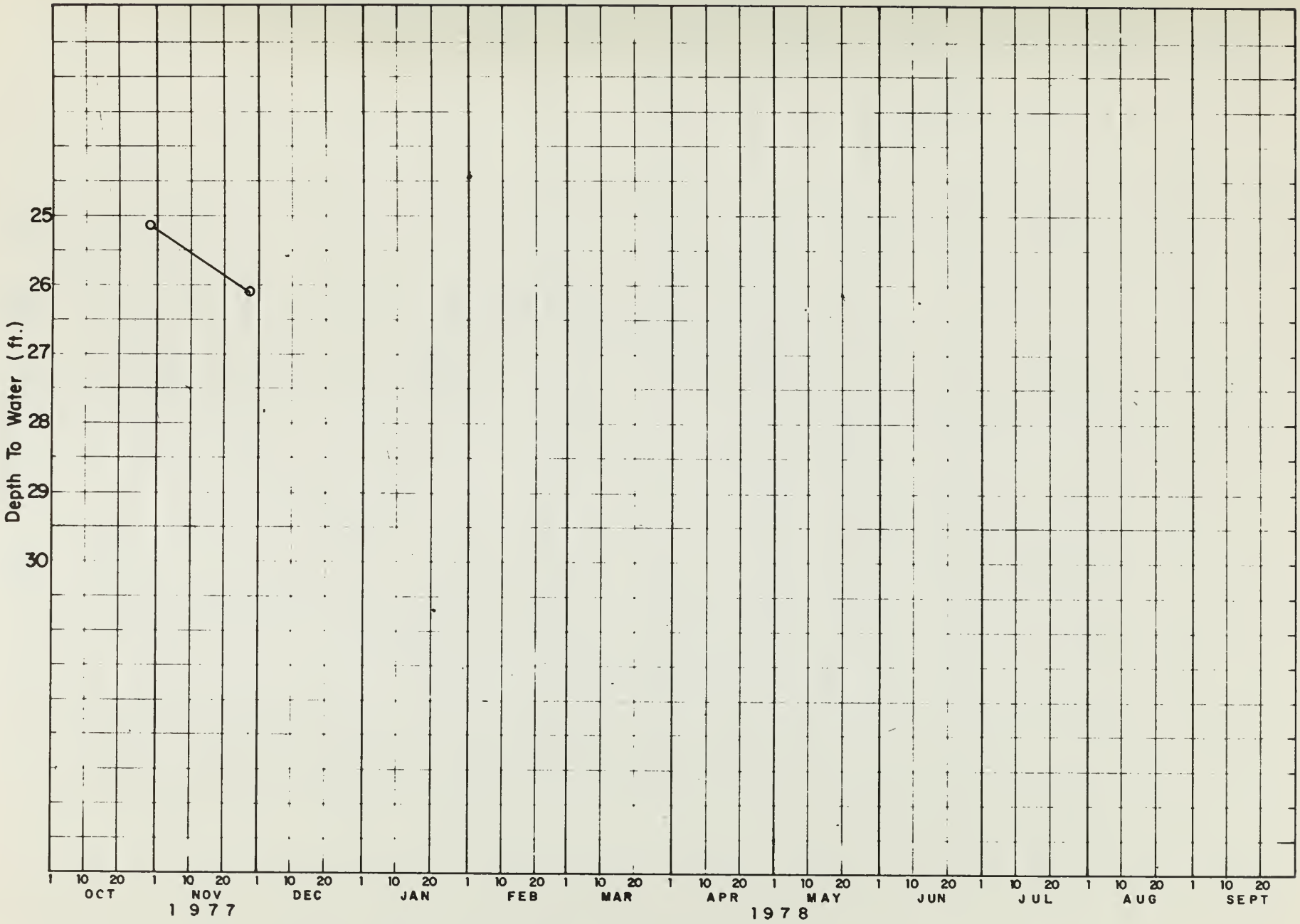

Figure 5-7. Depth to Water, Water Year 1978, Alluvial Hole G-S S-27

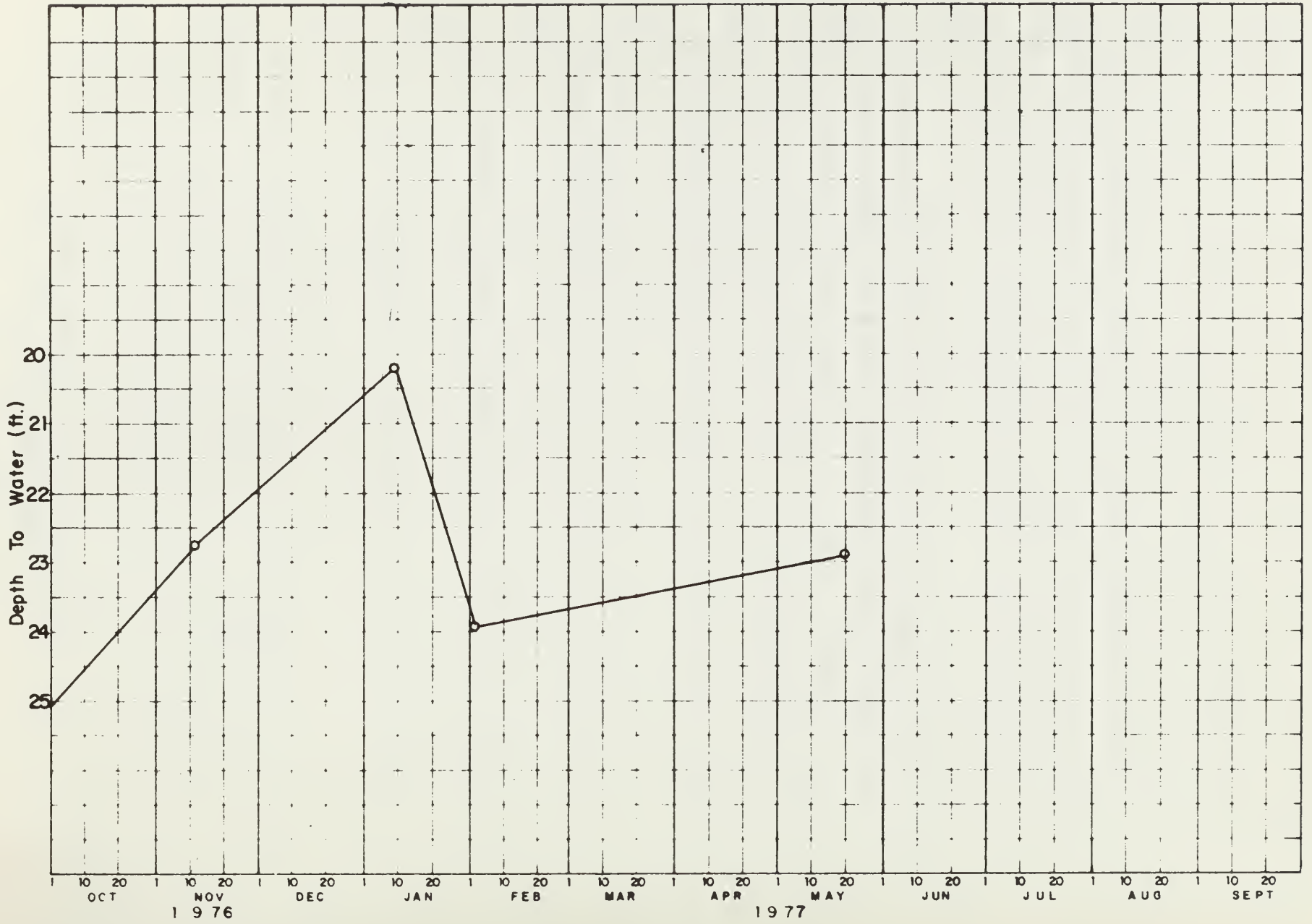

Figure 5-8. Depth to Water, Water Year 1977, Alluvial Hole G-S S-7.

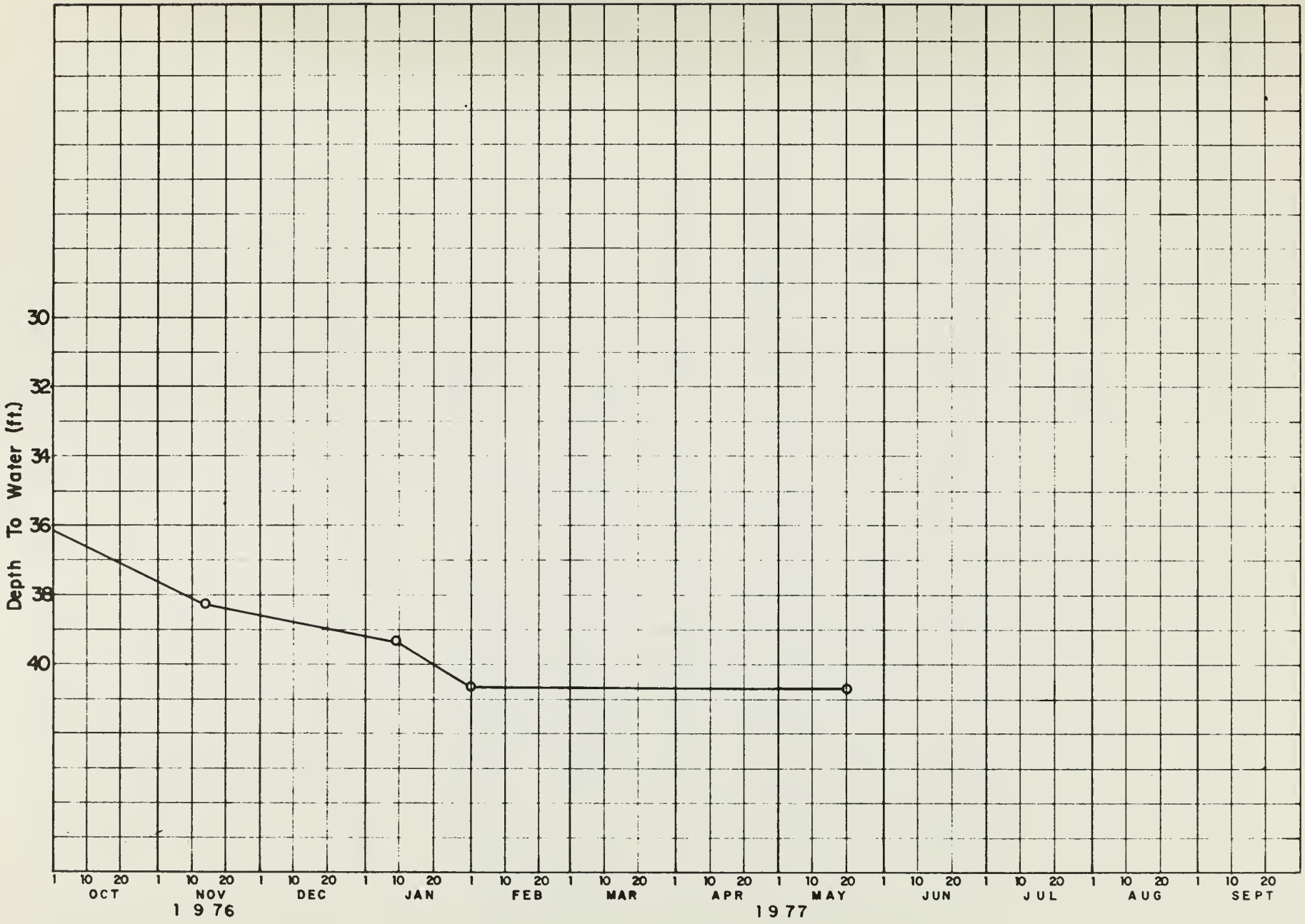

Figure 5-9. Depth to Water, Water Year 1977, Alluvial Hole G-S S-8.

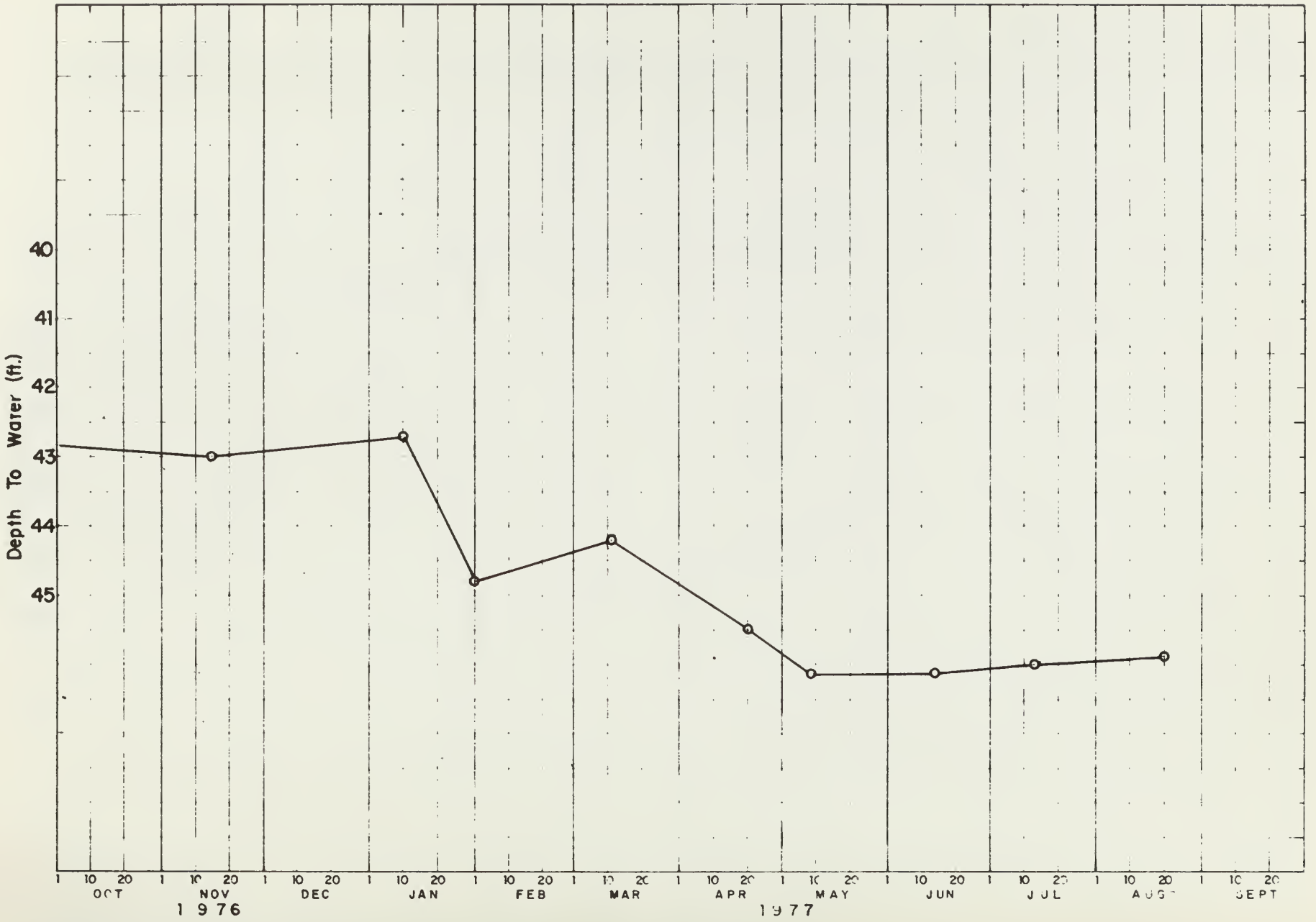

Figure 5-10. Depth to Water, Water Year 1977, Alluvial Hole G-S S-11.

A description of the two new alluvial holes drilled during this program is presented in the Appendix.

B. Deep Oil Shale Aquifers

1. Objectives

The purpose for this groundwater monitoring is to measure water levels in the upper and lower oil shale aquifers to ascertain the response to dewatering and reinjection.

2. Methods

Water levels are continuously measured at four locations: G-S M1, CE-702, G-S 11, G-S 15 (Figure 5-1).

3. Results and Discussions

Continuous water level recorders were installed in G-S M1, CE-702, G-S 11, and G-S 15 on November 26 and 27, 1977. Water level data collected with an electric wireline probe before installation of the recorders are presented in Figures 5-11 through 5-16, and Table 5-7. All water level readings taken with the probe are corrected for height of the measuring point above the ground surface and measurement errors in the wireline.

G-S 4-5 was monitored continuously throughout the interim period to provide continuity between the baseline period and the MDP. Note that water levels measured at G-S 4-5 since the beginning of the Interim Studies Program reflect a continuation of a slight downward trend that has been presented all year.

Because October 1977 was the initiation of the MDP monitoring program, water levels were measured in all deep aquifer holes (Table 5-7). Comparison of these water levels with measurements taken in October 1976 (Table 5-8) shows no significant change in the upper aquifer and a general water level drop of approximately six feet in the lower aquifer. This drop is a gradual trend

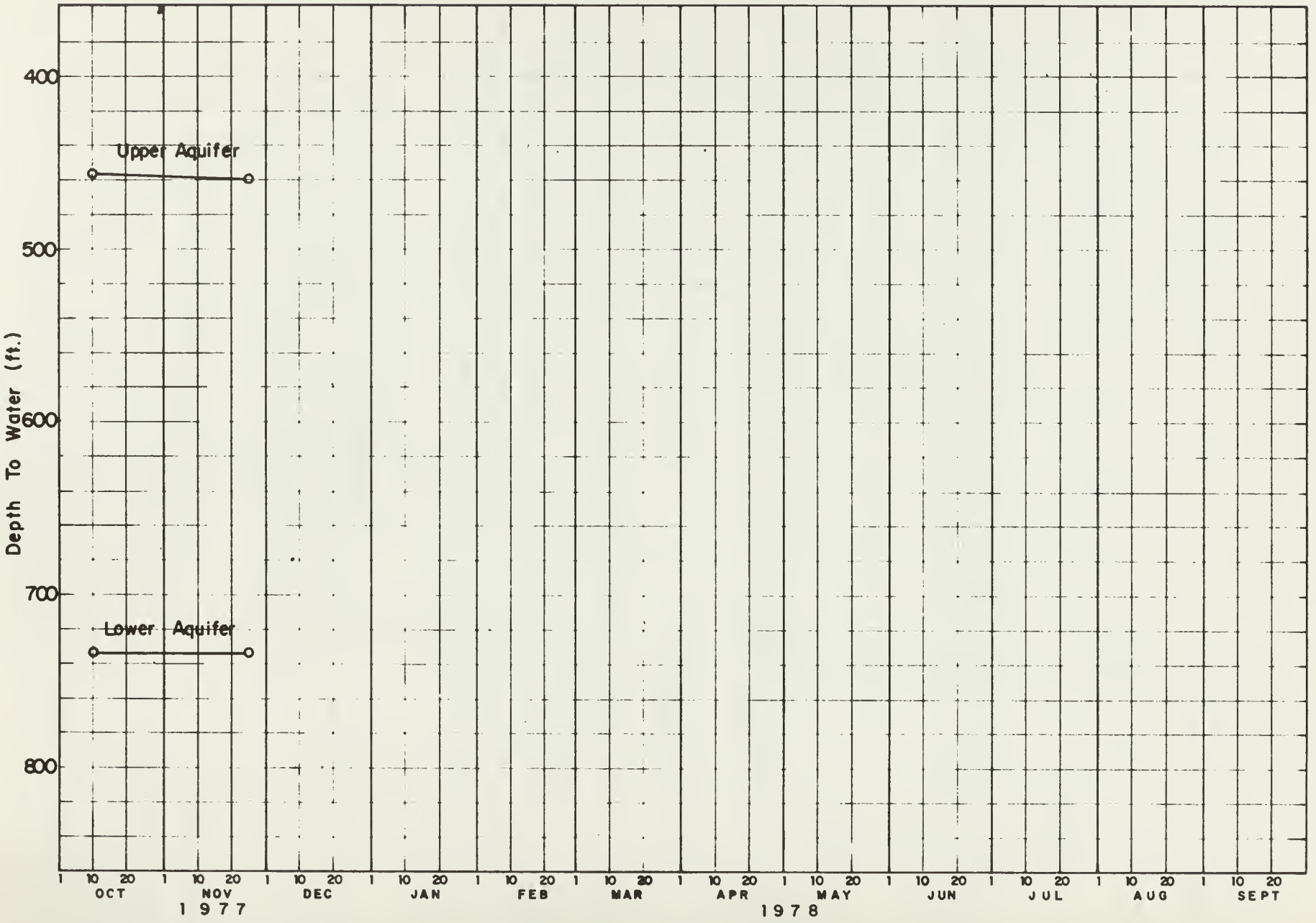

Figure 5-11. Depth to Water, Water Year 1978, Deep Aquifer Hole G-S 11, Upper and Lower Aquifer.

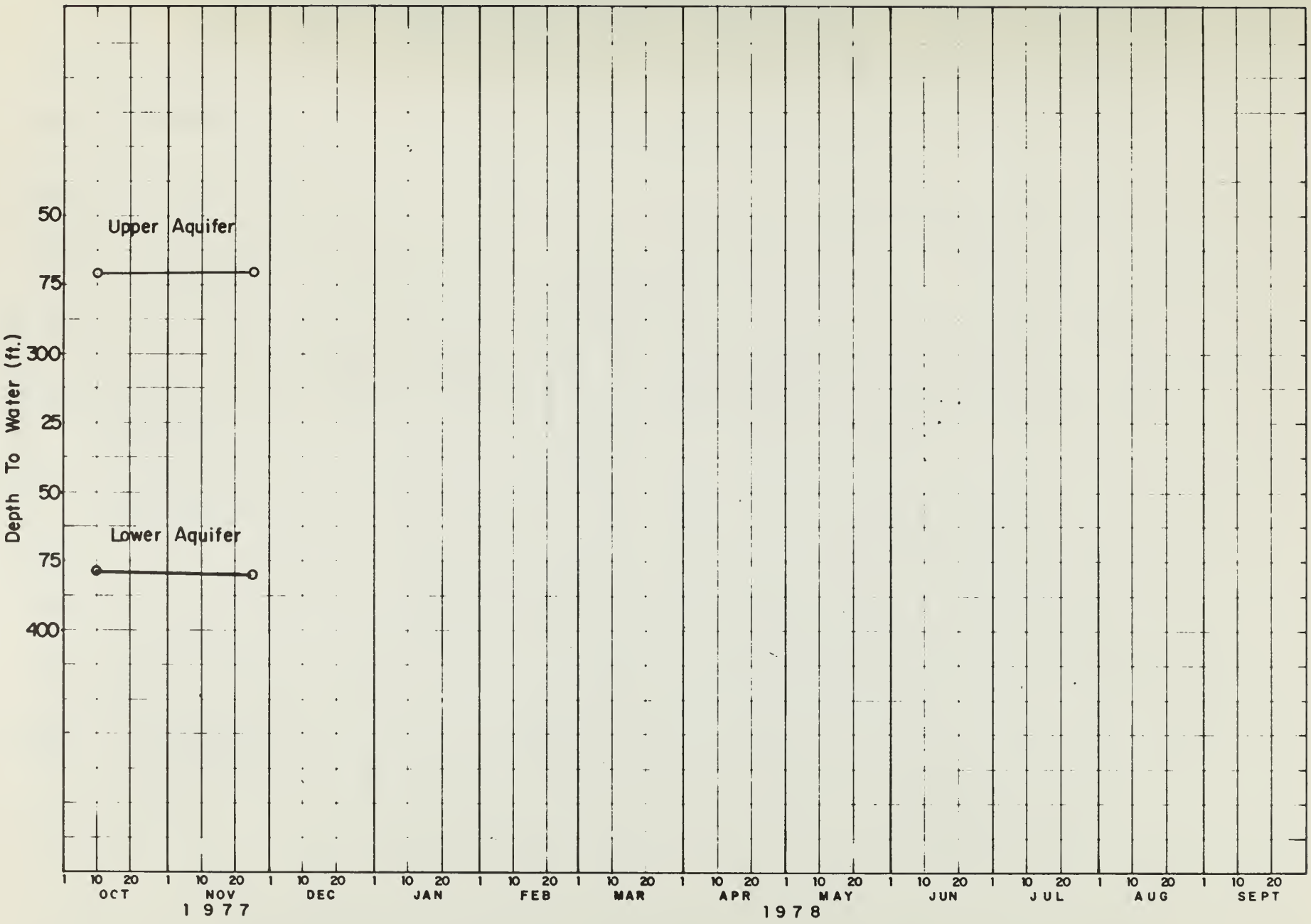

Figure 5-12. Depth to Water, Water Year 1978, Deep Aquifer Hole G-S 15, Upper and Lower Aquifer

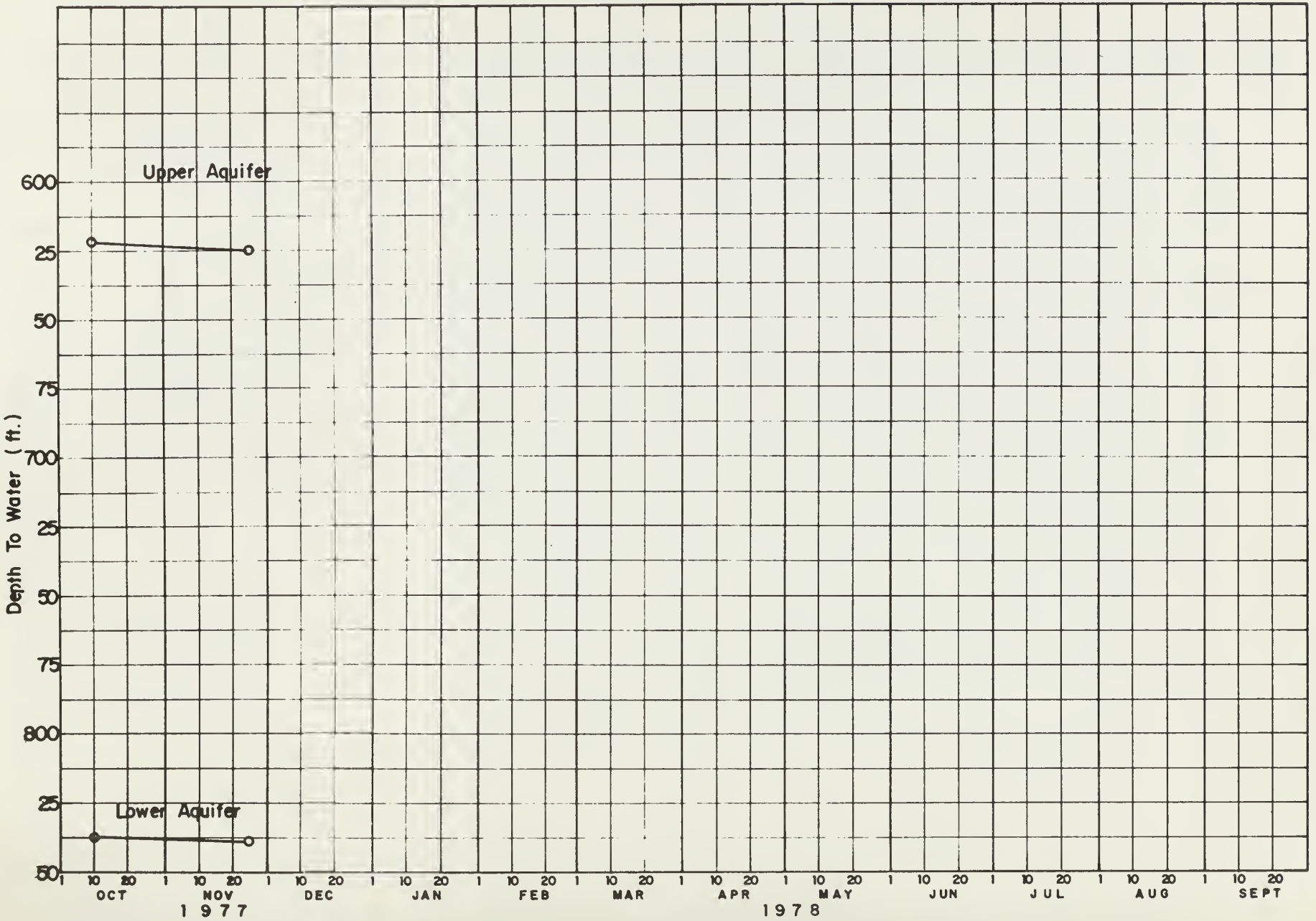

Figure 5-13. Depth to Water, Water Year 1978, Deep Aquifer Hole G-S M-1, Upper and Lower Aquifer

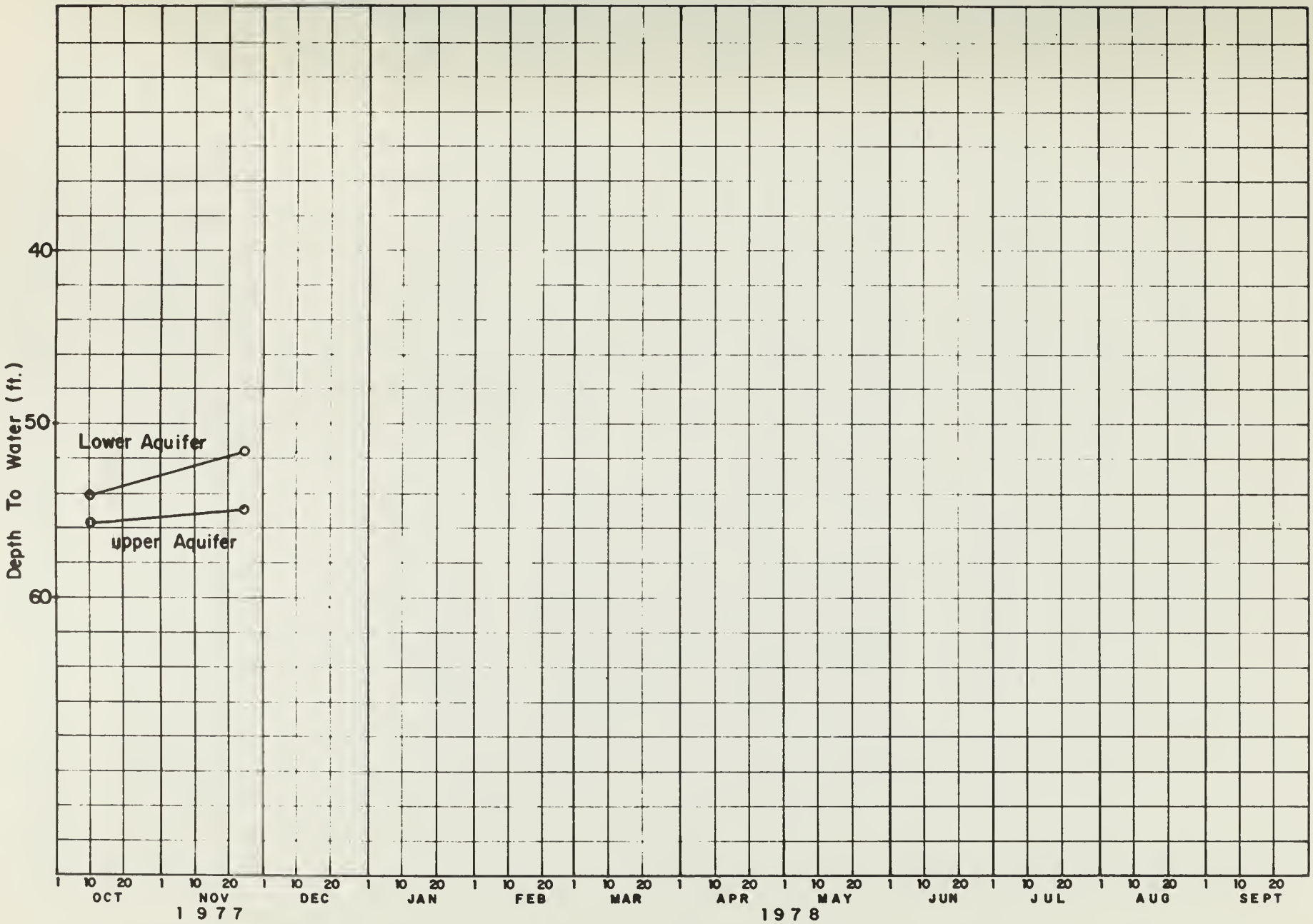

Figure 5-14. Depth to Water, Water Year 1978, Deep Aquifer Hole CE702, Upper and Lower Aquifer

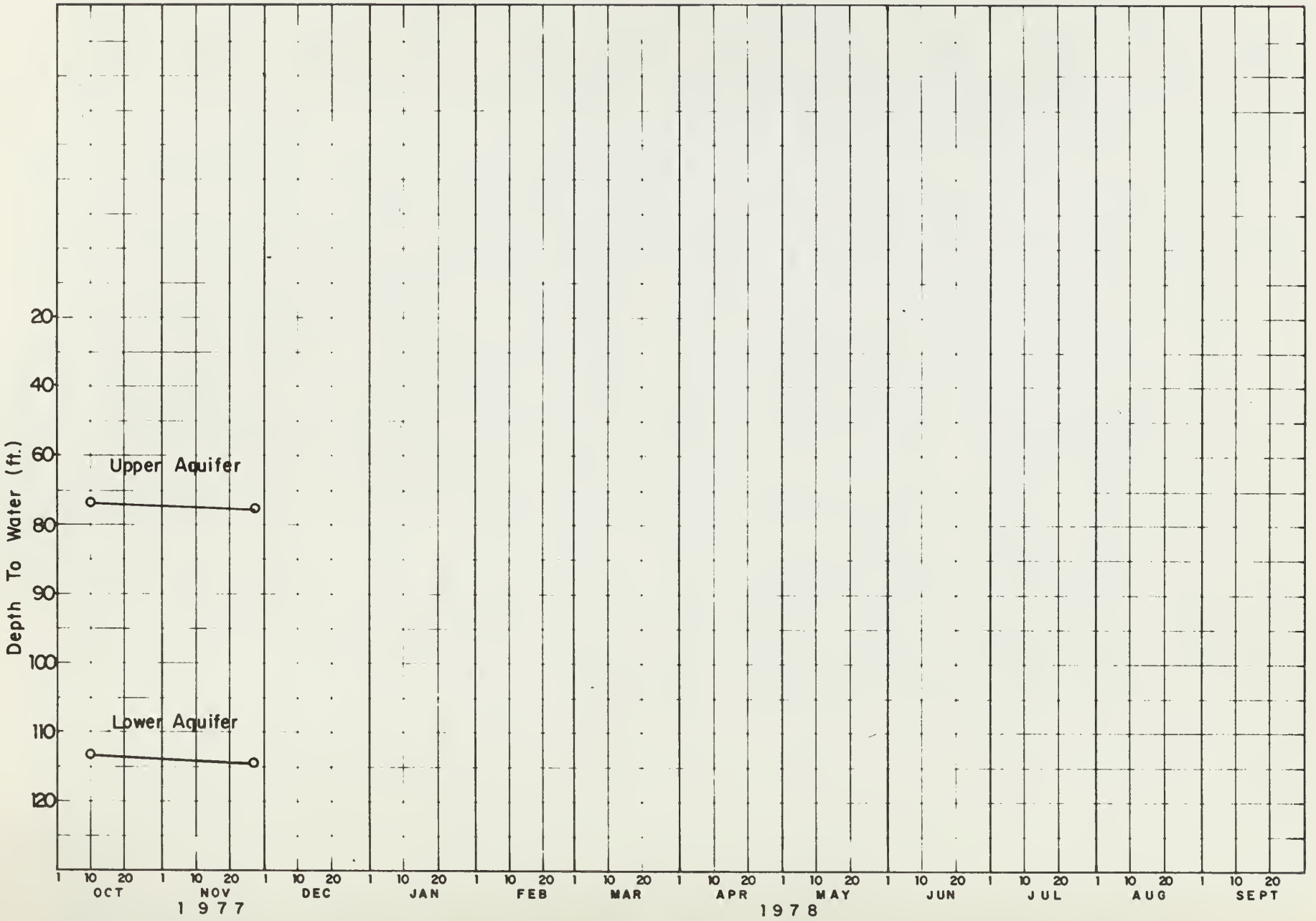

Figure 5-15. Depth to Water, Water Year 1978, Deep Aquifer Hole G-S 4-5, Upper and Lower Aquifer

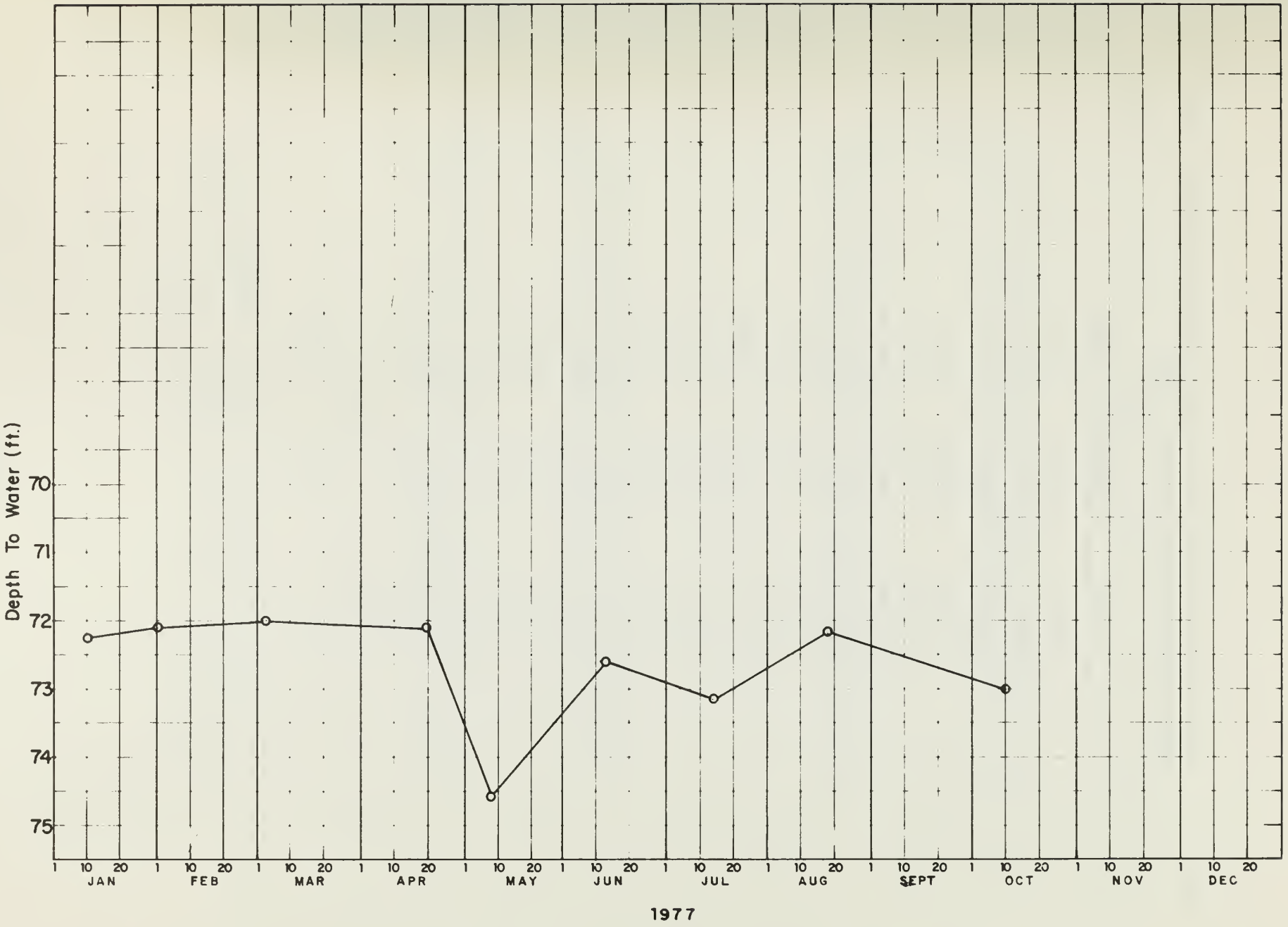

Figure 5-16. Depth to Water, Water Year 1977, Deep Aquifer Hole G-S 4-5, Upper Aquifer.

Table 5-7. Upper and Lower Aquifer Water Level, Measured During October 1977 Below Ground Surface (in Feet). RBOSC

Hole	Aquifer	
	Upper	Lower
AM 2A	376.43	653.01
AM 3	35.98	326.42
CE 702	55.89	54.23
CE 707	254.28	581.63
CE 708	54.69	313.04
CE 709	38.56	169.98
G-S 1	249.41	604.80
G-S 2-3	97.76	270.23
G-S 4-5	73.42	113.70
G-S 6	59.60	57.58
G-S 9	327.46	526.50
G-S 10	340.01	405.28
G-S 11	456.91	737.55
G-S 12	384.18	664.90
G-S 13	385.73	590.44
G-S 15	271.79	380.19
G-S M-1	624.67	838.13
G-S M-2	219.61	356.28
G-S M-3	16.40	142.67
G-S M-4	495.92	570.36
G-S M-5	236.81	
TO-1	25.32	142.85
TO-2	110.70	372.22

Table 5-8. Upper and Lower Aquifer Water Level Below Ground Surface in Feet, October 1976 through September 1977.

Hole	Upper Aquifer		Lower Aqufier	
	Oct. 21	Nov. 14	Oct. 21	Nov. 14
AM 2A	378.27	378.20	647.15	647.49
AM 3	33.15	34.81	320.55	318.82
CE 702	54.19	54.34	48.98	49.18
CE 707	251.90	251.68	575.77	576.22
CE 708	48.59	49.39	308.55	309.09
CE 709	33.88	33.71	164.26	164.67
G-S 1	243.26	243.92	601.94	602.02
G-S 2-3	98.23	98.06	264.46	264.89
G-S 4-5	72.39	73.59	107.84	105.19
G-S 6	56.02	54.14	53.81	56.19
G-S 9	318.49	319.64	520.87	521.17
G-S 10	339.53	339.40	399.71	396.97
G-S 11	455.91	457.02	731.42	731.96
G-S 12	383.58	384.79	659.25	659.62
G-S 13	386.06	384.15	584.46	584.91
G-S 15	272.06	272.20	374.34	374.81
G-S M-1	620.96	622.15	832.65	834.60
G-S M-2	222.65	221.98	355.52	353.85
G-S M-3	17.96	17.85	141.45	143.07
G-S M-4	493.62	493.84	568.79	569.50
TO-1	23.54	23.64	137.28	137.61
TO-2	110.85	111.42	366.39	366.86

which is also reflected in the spring water level measurements. This is accounted for by lack of recharge due to minimal snowmelt runoff in spring 1977. We can conclude the MDP activities have had no significant effect on water levels in the deep oil shale aquifers.

For the remainder of the MDP monitoring program, measurements will be taken only at G-S M1, CE-702, G-S 11, and G-S 15.

SEC

SECTION 6

SUMMARY

Modular Development Phase environmental monitoring activities were initiated on Tract C-a in September 1977. This program is multidisciplinary and includes air quality, meteorology, terrestrial ecology, aquatic ecology, and hydrology studies.

The Tract C-a atmospheric studies program consists of two discrete parts--(1) measurements of total suspended particulate matter and certain chemical compounds in the ambient air, and (2) measurements of meteorology parameters to characterize the climatology of the tract area. During this reporting period, the level of activity in tract development was very low. One air quality and meteorology monitoring station was operated continuously throughout the reporting period, and two additional stations were re-established in anticipation of the start of the Modular Development Phase of tract development.

Air quality parameters measured during the reporting period included sulfur dioxide, hydrogen sulfide, nitrogen oxides, carbon monoxide, hydrocarbons, ozone, and particulates. Readings obtained from continuous recording instrumentation continued to indicate levels below the reliable threshold of detection for sulfur dioxide, hydrogen sulfide, nitrogen oxides, and carbon monoxide. Hydrocarbons were detected in concentrations up to 2.5 ppm. However, uncertainties in the detection methods leave the significance of this value in doubt. Ozone concentrations were measured using two different techniques, which yielded different results. Particulate levels measured during this period at Site 1 (maximum = 25.3 $\mu g/m^3$) were comparable with measurements taken during the interim study period.

Meteorology measurements taken during the reporting period included wind speed and direction, air temperature, precipitation, insolation, and relative humidity. Prevailing winds were from the southwest. Precipitation data were taken using three different measurement techniques. The differences among the three methods appear to be unreasonable and are as yet unexplained. Analysis of this problem is continuing. Insolation data indicate that the period was mostly clear. Relative humidity varied from 11 to 91 percent.

Two other programs are planned but have not been initiated--visibility and noise. Data from these studies will be presented in future reports.

Terrestrial studies sampling sites have been selected and mapped. Soils studies aren't scheduled to begin until 1981, just prior to the first retort burn. Vegetation mapping, range, and browse studies are scheduled for spring 1978. Over 1200 mule deer pellet-group plots were established in September 1977. Counts will be made in the spring of 1978. Feral horse aerial surveys will be conducted during the winter of 1978. In addition, opportunistic surveys for horses and threatened or endangered species are being conducted by environmental personnel on the site.

Six aquatic sampling sites were visited during October 1977. Data collected included physical measurements (velocity, turbidity, dissolved oxygen, pH, specific conductance, depth, width, substrate), and periphyton and benthos population data. Additional water quality measurements were taken for two stations in the White River.

The data indicate that physical measurements at the stations studied have been similar in October of the three study years. Water quality data from the White River show increases in concentrations of most parameters measured from 1975 to 1977. Dissolved sulfate was an exception. These increased concentrations are attributed to drought conditions.

Biotic data taken during October 1977 varied randomly from values obtained during earlier years, making it impossible to identify trends from one year to the next. No explanation for these variations is apparent.

Hydrology studies conducted during the first quarter of the MDP Monitoring Program included surface water quantity and quality at six gaging stations, flow and conductivity measurements of six springs and seeps, water level and quality at eight alluvial aquifer monitor holes, and water levels at four deep aquifer monitor holes.

Surface water quality data from the USGS is available for only one gaging station. These data compare favorably with baseline data for the same location. Data from springs and seeps were also similar to baseline data, except for flow which varied among the various years at the same locations.

Water level in the alluvial aquifers was lower than at the same time last year. This is attributed to current drought conditions. Water quality of alluvial sources is similar to baseline.

Water levels in the upper deep aquifer are similar to levels measured during baseline. However, there appears to be a general water level drop (about six feet) in the lower aquifer. This is also attributed to lack of surface recharge.

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